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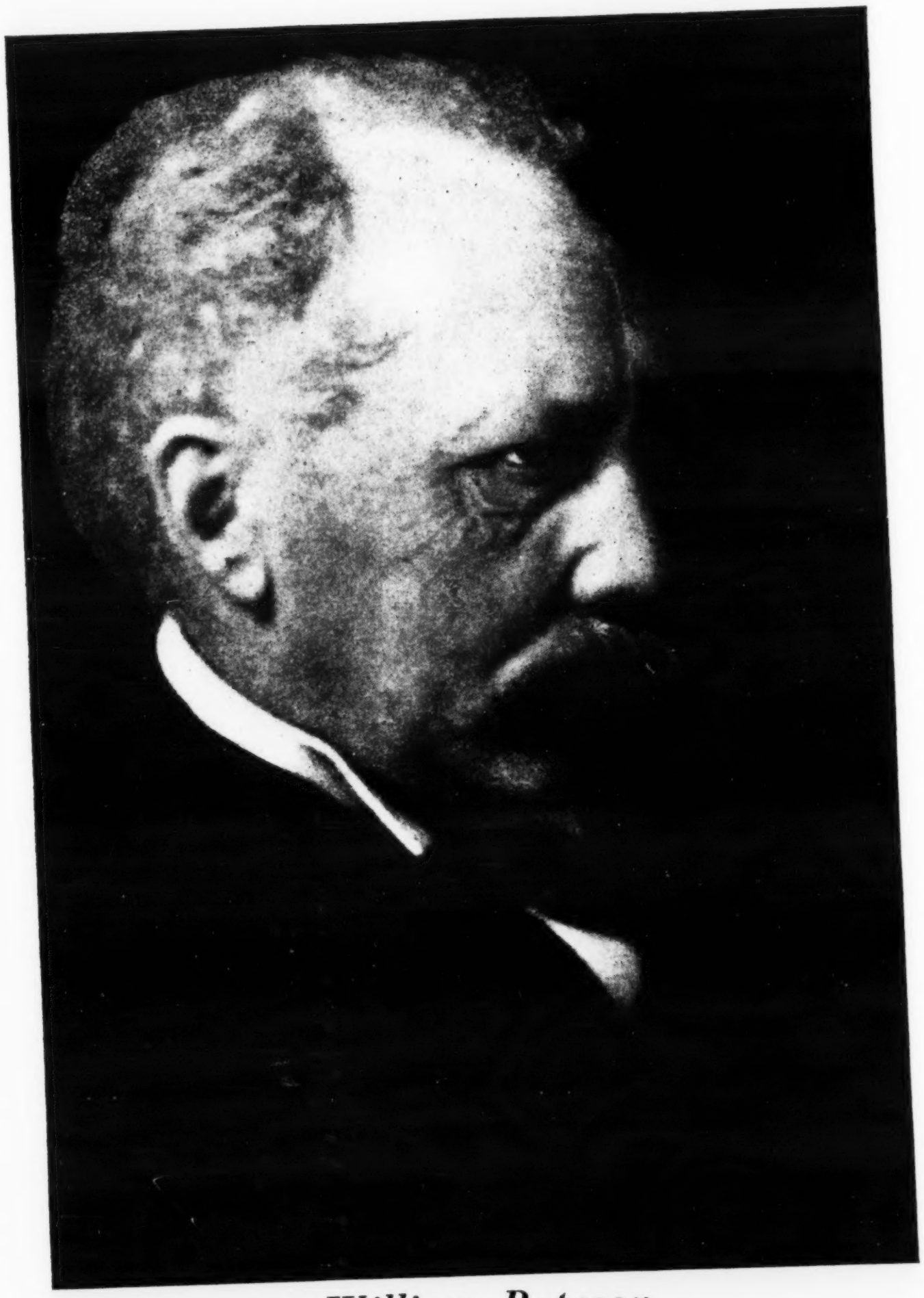

*William Bateson*

X-Ray-Induced Lethals in Datura

Earless Sheep

Inheritance of Huntington's Chorea

VOLUME 21 MARCH, 1930 NUMBER 3

# The American Genetic Association

***An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks***


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*The*

# Journal of Heredity

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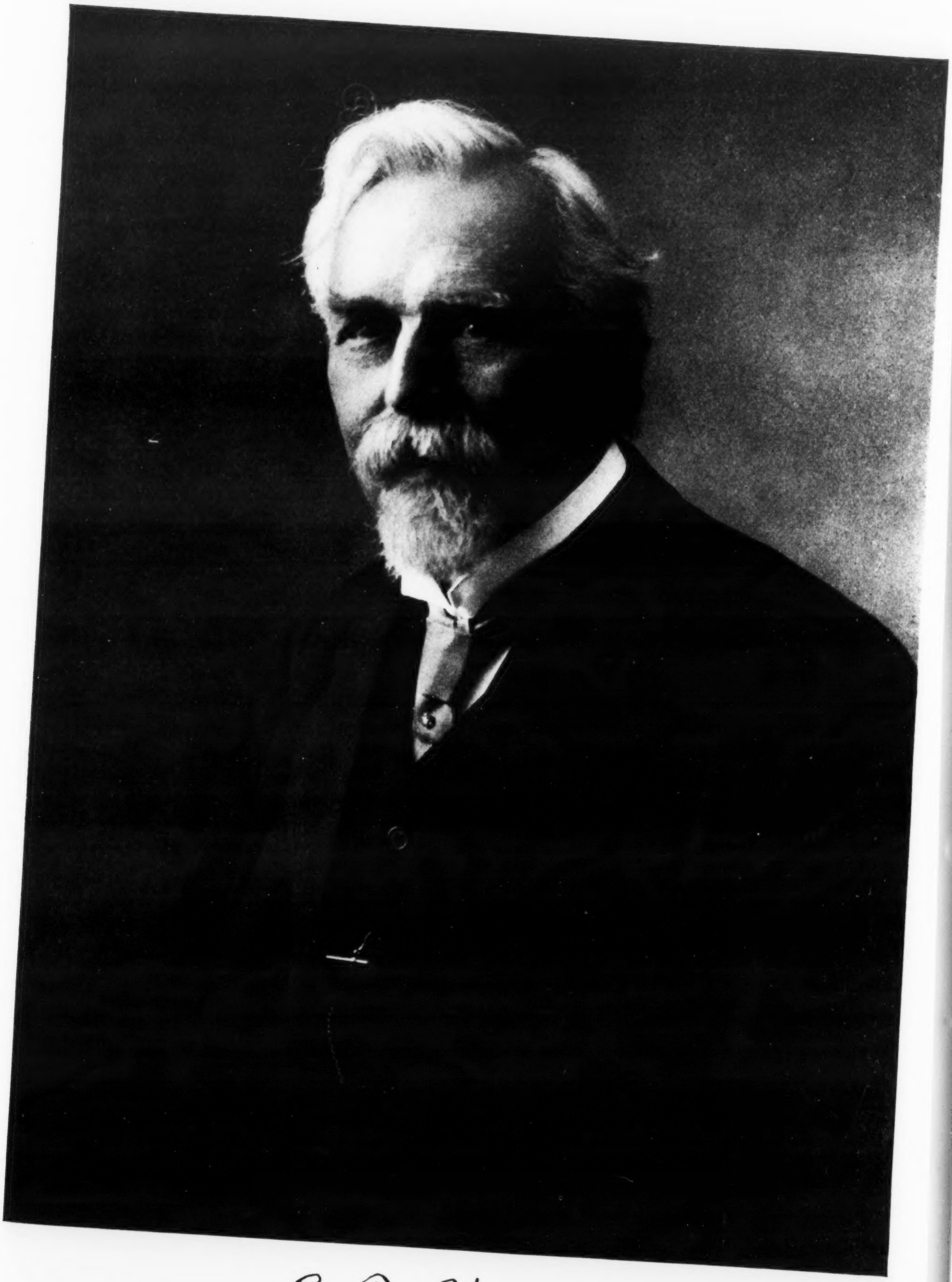


S. P. Rixford

# RIXFORD--VETERAN PLANTSMAN

## Awarded the Ninth Meyer Medal by the Council of the A. G. A. for Distinguished Service in Plant Introduction

W. C. TESCHE*

IT is the idle machine that rusts, and the soft metal that wears. And so it is with humans.

Gulian Pickering Rixford's career exemplifies that rare combination in human flesh, an inherited longevity that resists wear and the will to fight rust with work, blended with a spiritual quality that sees in each sunrise a happy opportunity to carry on yesterday's task or to initiate a new one. To such a spirit the sunset is merely the forerunner of another dawn.

To one of a younger generation, the recording of some of the high lights and accomplishments of such a career becomes a rare privilege and an inspiration.

Over ninety-one years of zestful living! Though his retirement from the Government service in 1929 and the conferring of appropriate honors upon him by his associates mark the incentive to write this sketch, to Mr. Rixford retirement shortly after his ninety-first birthday was merely another passing sunset. There was work to be continued on the morrow.

With each planting of a tree or shrub he optimsitically extends his anticipated life-span another notch. Thus, during a visit to the Rixford ranch at Los Altos, in the western foothills overlooking the Santa Clara Valley, California's "Valley of Heart's Delight", the writer commented upon the time required for certain trial plantings to reach fruiting. The characteristic Rixfordian reply was: "Why, of course, but if I didn't expect to see them fruit, why do you suppose I'd be planting young trees? I'm just a youngster and have quite a bit of work planned for the next few years."

On October 25, 1929, several days before the announcement of his retirement,† the Frank N. Meyer medal was conferred upon Mr. Rixford at Merced, California, by Dr. C. B. Hutchinson, Director of the Giannini Foundation of the University of California, representing the American Genetic Association. Though temporarily stricken with illness a short time previous, the recipient was on hand for the ceremony. And particularly appropriate was the fact that its occasion was the banquet of the Fifth Annual California Fig Growers' Institute. What was more fitting than that the father of the Smyrna fig industry in California be so honored in the presence of fig growers!

In transmitting the medal, the committee of award said:

> The American Genetic Association has been entrusted by members of the Office of Foreign Plant Introduction of the U. S. Department of Agriculture, with the awarding of a medal struck in memory of Frank N. Myer, its agricultural explorer, who lost his life in China. The award is made for distinguished service in the field of foreign plant introduction.
>
> The Council of the Association has selected you, Gulian P. Rixford, of San Francisco, California, to receive this medal, the ninth to be awarded. Through your persistent effort, in spite of discouragements, delays and difficulties, the Smyrna fig was introduced into California. You have developed improved varieties of Caprifigs and in many other ways have furthered the fig industry. In addition to your outstanding contributions to fig culture, you early devoted your energies to the introducing into California of seeds and plants of rare and unusual varieties, among them the casaba melon. You are now actively engaged in aiding the

---

*Horticultural Editor, *The Pacific Rural Press*, San Francisco, California.

†EDITOR'S NOTE—Upon recovery from his illness, Mr. Rixford was reinstated by the Department of Agriculture so that the Government is still enjoying the benefit of his long experience and his activities in horticultural studies. He will retire on August 20, 1930.

establishment of the pistache nut as a commercial crop, and in furthering the avocado, persimmon and pomegranate industries.

The results of your labors are preserved in living memorials in the orchards and gardens of California and the Southwest. The horticulture of this region has been permanently enriched through your zeal, enthusiasm and devotion through a period of over fifty years.

In recognition of these services it is with great pleasure that the Council of this Association awards you the Frank N. Meyer Memorial Medal of Foreign Plant Introduction.

Thus were culminated twenty-one years of service as crop physiologist in the Bureau of Plant Industry, plus at least twenty-eight preceding years of "amateur" activity, during which, though occupied with other affairs, the practice of horticulture as an avocation resulted in the initiation of projects which were to bring honor and inspiration for further work in later years.

It is fair, then, to state that from 1879, when he first conceived the idea of introducing the famed fig of Smyrna, to 1929, when he "retired" from active service, fifty years of his life were devoted more or less continuously to the upbuilding of the horticultural industry. His was a vital rôle in the evolution of California's great horticultural enterprises.

## Early Life

Gulian Pickering Rixford was born at East Highgate, Vermont, on September 21, 1838. The family had been engaged in scythe-making for many years near Winchester, New Hampshire, and later at East Highgate. In 1850 the business was divided and Luther P. Rixford, father of Gulian, moved across the Canadian border to Bedford, Province of Quebec, where good water power was available, while his brother, O. S. Rixford, continued making scythes and later axes at East Highgate. This factory, still in the family, is making scythes and axes today, a record of continuous production for over 120 years.

Moved to Canada at the age of twelve, the transplanted son of Vermont found himself rapidly learning the secrets of tempering steel and other mechanical processes.

But education was not neglected and after preparation at the Academy, Stanbridge East, Province of Quebec, the young scythe-maker who was later to become an expert horticulturist entered McGill University at Montreal in 1862 to study civil engineering. He graduated in May, 1864, a year marked by another important event in his life. He married Caroline Corey soon after graduation.

Shortly he received his certificate as Provincial Land Surveyor after the customary examination and proceeded to the practice of his profession. For two years, working for a prominent engineering firm, he was engaged in construction work, including the laying out of a street railway in Quebec, a railroad from St. Johns, Province of Quebec, to Swanton, Vermont, and a bridge or two, said to be still in service.

Then, in 1867, a momentous decision was made in the Rixford family. The call to adventure, the lure of the West and "California fever" could not be denied, and the early part of that year while the nation was in the throes of reconstruction saw a family of three do what millions have since done—follow the westward course of empire.

From the fact that there were three in the family at that time, one correctly infers that a child had been born. Emmet P. Rixford, now an eminent surgeon in San Francisco, was born in 1865 in Bedford, Canada, and accompanied his parents westward. Three younger children were subsequently born in the West, in 1868, '70 and '73. They are Geneve (Mrs. Geneve R. Sergeant), Loring Pickering Rixford, architect, and Caroline (Mrs. B. C. Byrd). All are living, testifying to the staunch stock from which they sprang. The mother passed away in 1913.

The trip West was slow but fascinating, we may assume. The journey was made over the Vanderbilt or "Opposition" line via the Isthmus of Nicaragua. Crossing was made through Nicaragua

via the San Juan River. Because the water was low the party was placed on barges pulled by wading negroes, then across Lake Nicaragua, thence transferred by muleback to Aspinwall, where a west coast steamer carried them northward to San Francisco.

Off the coast of Mexico the steamer broke one side-wheel drive shaft and put in at Cape St. Lucas. There the commandante, friendly to the competing Pacific Mail line, conspired to prevent their sailing but the resourceful skipper got away in the face of heavy weather and finally made San Francisco on April 11, 1867, just at dark, two years after the close of the Civil War.

The twenty-nine year old civil engineer was hardly a stranger to horticulture in spite of his professional career, because it is a matter of family pride that even in Vermont and Canada he showed a knack for propagation and a love of plants. And we may well imagine that the trip through the Central American tropics was a revelation and an inspiration to this hobbyist. In later years, when plants claimed all his interest, he was to make several trips back into Central America.

But 1867 saw the Rixford family established in San Francisco, and of course, a job was a consideration of importance. Skilled mechanics and engineers were not long idle in those days and the head of the house was soon employed in a machine shop where his training in handling steel and tools stood him in good stead.

After a year, however, a more active life involving contact with public affairs attracted him, and he accepted a position with the San Francisco *Call and Bulletin,* of which an uncle, Loring Pickering, was senior partner. This may be marked as another turning point, because it was during his twenty-one years with the newspaper that his interest in horticulture grew from mere curiosity to intensive study, thence to accomplishment and the final attainment of prominence among California plantsmen.

For twelve years he served as commercial reporter and editor, starting as a reporter on the San Francisco produce markets in 1868. There, daily, he saw the arrival of produce of all kinds, an experience that must have swelled the urge to learn more about the fascinating game of production.

His last nine years in newspaper work were spent as business manager of the *Bulletin,* and with this advancement his interest in plants was resolved into action. Obviously, his job called for the building of a newspaper, and to attract readers, especially those at country points to which the weekly edition was sent, it was customary to offer premiums with subscriptions. But why waste money on trinkets of little permanent value, thought Rixford. An expanding agricultural industry deserved something more constructive, so why not offer cuttings and seeds of new varieties?

And so was born the search for and introduction of the Smyrna fig—in 1880. By combining business-getting duties with his hobby he introduced seeds of many new vegetables and flower varieties, an undertaking which immediately identified him with the horticultural progress of the country. In 1880 he began to keep his scrap book of clippings from the daily and agricultural press of the country, a collection which was to grow to unusual size and historical significance, and which today reposes in a fireproof safe furnished by his co-worker and chief, Dr. Walter T. Swingle of the Department of Agriculture. Systematically through the years he filed all interesting items and articles about California fruits. According to his son, Dr. Emmet Rixford, bureau drawers were temporarily stuffed with them against rainy days when the family was put to work assisting in arranging, pasting and indexing them.

When the late E. J. Wickson arrived in California, Rixford took him in tow—showed him the ropes, in other words—and in later years, this beloved horticulturist, teacher and writer was wont to refer to Rixford as his "introducer."

**A THRIVING SMYRNA FIG ORCHARD IN CALIFORNIA**

**Figure 1**

Calimyrna fig orchard in full bearing, near Fresno, California, September 21, 1924. There are more than fifty thousand acres of fig orchards in California today, which produce an annual crop of some forty thousand tons of fresh figs, with a value to the growers of nearly two million dollars. This entire industry owes its origin to the enterprise of G. P. Rixford in introducing the Smyrna Fig, and to the investigators who discovered why the newly-introduced trees failed to set fruit. Plant introduction is beneficial in two ways. It gives us new crops that from small beginings sometimes grow with amazing rapidity into industries that become the main support of large numbers of people, or of entire communities. It also furnishes new material for the plant breeder, which of little value directly, becomes the basis of improved varieties through hybridization. In the future this latter function of plant introduction will probably prove the most important

**THE THREE MEN WHO MADE POSSIBLE THE CALIFORNIA SMYRNA FIG INDUSTRY**
**Figure 2**

G. P. Rixford, seated, who imported and distributed the first cuttings in California; Dr. Gustav Eisen, standing, who first discovered the necessity for caprifying Smyrna figs; and Dr. Walter T. Swingle, examining fruits, who introduced the Blastophaga insects, making crops possible. From a photo taken some twenty years ago.

Meanwhile he spent considerable energy in directing the newspaper's affairs, and won the distinction of introducing and using the first stereotyped plates on the Pacific Coast, long before the first rotary press was invented. But in 1889 he retired to private affairs. Subsequently for several years he was manager of the Inyo Marble Company.

Along with his burrowings into horticultural science he took an active interest in organization affairs and served for five years as secretary of the California Academy of Science, and is still a member of the Council. His contributions to newspapers, agricultural journals and scientific works were numerous. What was first a matter of interested curiosity and then a hobby became a serious and absorbing part of his life, and along with the growth of his clipping file he became an inveterate and careful note-taker. His valuable collection of original notes reposes in the safe along with his clippings.

With all his activities, and unquenchable curiosity, Rixford became a walking plant introduction station! By correspondence with consuls over the world he imported numberless novelties and improvements, among them the nutmeg melon from France (from which the Rocky Ford cantaloup was bred), the Telephone pea from England, a number of tomatoes, grapes from the Levant, lilies from Japan, and other flowers, and the Casaba melon.

The last-named introduction, a fruit of considerable value in California today, was made through Dr. J. D. B. Stillman, who discovered the melon while travelling in the Levant as companion of the son of Senator James G. Flood and sent seed to California. Rixford grew it and distributed the seed to subscribers to the *Bulletin*. Named after Kassaba near Smyrna and of Arabic origin, Rixford, quoting Stillman, insists that the common accenting of the middle syllable is in error; the first and particularly the last syllables are properly to be stressed.

An interesting and significant reflec-

**A PLANTS MAN AND SOME OF HIS PETS**
**Figure 3**

Among the subtropicals with which G. P. Rixford is experimenting on his Los Altos ranch in the thermal belt of Santa Clara County is the cherimoya. Here, in his 92nd year, he is shown alongside some of his pets.

tion of his foresight and observance of detail lies in the fact that even before the enactment of rigid quarantine laws, while an understanding of foreign pest introduction was still meager, he carefully fumigated all imported cuttings with carbon bisulfide before opening them.

During all these years his children were growing and taking their places in the world. To add to his joy, his father and mother had followed the younger Rixford family to California shortly after the overland railroad had been completed. A brother, the late E. H. Rixford, became a prominent attorney in San Francisco; but he too found delight in horticulture, and picked viticulture and wine-making as a hobby, subsequently becoming an authority of standing and an author of a book on the latter subjects, *The Wine Press and The Cellar*.

The elder Rixfords purchased a ranch near Sonoma, which, we take it, became the "Rixford Experiment Station," used by all members of the family. It was there, Dr. Emmet Rixford recalls, that his uncle and he launched upon an amateur experiment in olive oil making that was to bring a bit of distinction to the family.

The olives were picked and carefully dried in the attic. During the winter a mortar and pestle were made out of a milk can and a club, the olives were ground and the juice squeezed through a wine press on a cold day. The heavy

oils wouldn't run, so only the light oil came off, and this was set in stone crocks for three months and carefully skimmed and dipped off. The result was a very delicious light oil. In 1889 two pint bottles were filled and furnished with special labels printed for the occasion, and sent to the exposition at Paris. The exhibit was awarded one of the two medals won by California for olive oil, and the Rixfords had to pay for the cost of casting the medal!

### In the Government Service At Seventy

It is obvious that the name of G. P. Rixford circulated beyond the boundaries of his state. Members of the Department of Agriculture at Washington came to look upon him as an unofficial co-worker and frequently consulted him on matters pertaining to western horticulture. This relationship finally culminated in his acceptance of a position with the Department in 1908, first on a per diem basis and shortly thereafter on full time as Crop Physiologist in the Office of Crop Physiology and Breeding Investigations.

With this he found not only time for intensifying his famous fig studies, but also for breeding and adaptation work with citrus fruits, pistache nuts, avocados, passion fruit, and other tropical and subtropical plants. Several trips were made into Central America. Up to the time of his retirement last year, after some twenty-one years of official service at an age when most men are content to occupy arm chairs on front porches, he conducted a survey and study of avocado variety adaptations in central and northern California. Reports of his findings were written for the California Avocado Association, and the agricultural press during his ninetieth year!

### Introduction of the Smyrna Fig

It is around the Smyrna fig, of course, that much of Rixford's career in public service revolves, and the story of that introduction is best given in his own words, taken from Department Bulletin 732, *Smyrna Fig Culture,* of which he was author. This treatise, quite complete in detail and scope, was published in 1918, when the author was eighty years old! He says:

> Believing that the soil and climate of California were perfectly adapted to the growth of the Smyrna fig, the writer, who was at that time business manager of the *Evening Bulletin,* San Francisco, Cal., induced the proprietors of that journal to make an appropriation of funds to undertake the introduction from Asia Minor of the genuine Smyrna fig of commerce. In January, 1880, the assistance of E. J. Smithers, then United States consul at Smyrna, was enlisted in aid of the enterprise. A remittance was made to cover the expense of forwarding a small shipment of 500 cuttings, including a few caprifig cuttings. This shipment reached San Francisco on June 8, 1880, but owing to defective packing a considerable portion of the wood rotted and the season was so far advanced that the cuttings made but a feeble growth, although the greatest care was taken with them. However, 200 of them were saved and showed promise of becoming thrifty trees.
>
> About this time Mr. Smithers arrived in San Francisco en route to Chinkiang, China, to which consulship he had just been assigned. He stated that at the time the shipment was made he and the dragoman of the consulate at Smyrna had caused to be planted 4,000 cuttings, which had meantime become rooted trees and could be purchased at from 8 to 10 cents each, the usual price of trees in Asia Minor. Rather than disappoint the county subscribers of the paper who were expecting the promised trees that season, it was then determined to import the whole lot. Funds were therefore forwarded to an American merchant in Smyrna with instructions to purchase the trees referred to and ship them at once.

But in April, instead of trees, Rixford received a letter stating that the planter had been offered $1 per tree and could not part with them for export to this country at less than $1.25. Obviously, this discouraged further negotiations for the time being. He goes on to say:

> However, correspondence was kept up with the agent during the summer and in September, 1881, orders were sent to make a large shipment of cuttings, which it was found could be had at a reasonable price from one of the best orchards in the Meander Valley, the most important fig district in Asia Minor. Every precaution had been taken to assure the safe arrival of this consignment, even by shipping moss from New York in which to pack the cuttings. The cases on arrival in New York were re-

packed before being shipped across the continent by the southern route, as the season was mid-winter.

Th shipment consisted of 14,000 cuttings, including several varieties of the best Smyrna figs. It weighed several tons and arrived in excellent condition. W. B. West of Stockton, James Shinn of Niles, Governor Leland Stanford of San Francisco, and Dr. J. D. B. Stillman of Lagona, Calif., had shares in the importation, but the San Francisco Bulletin Company had the larger portion and paid the greater part of the expense. A large number of cuttings were distributed to 3,000 county subscribers of the *Bulletin*, while the individual shares went to the different partners of the enterprise. Governor Stanford planted most of his cuttings on his ranch near Vina, Calif., now the property of Stanford University. The trees resulting from this importation are now growing in all parts of California and other southwestern states. Some have attained gigantic size, a number recently measured by the writer having trunks three feet in diameter.

The problems, discussions and vexations which followed the introduction and failure of the Smyrna fig to mature crops are known to students of the industry. Dr. Gustav Eisen demonstrated that self-sterility and cross pollination were problems to be solved if the Smyrna figs of the Old World were to be duplicated here. He first demonstrated the need for caprification in 1885. In 1886 E. W. Maslin of Loomis took seed from imported Smyrnas and in '87 started his famous seedling orchard, which also failed to fruit. Finally, the Blastophaga wasp was successfully introduced by Dr. Walter T. Swingle and first colonized on the George C. Roeding ranch at Fresno in 1900. The Maslin seedling orchard was colonized the next year. It is interesting to note, however, that while this discussion and search were on, the insect was actually in California, having been accidentally introduced in 1865 and confined to several isolated trees on the west side of the San Joaquin Valley. These originated from cuttings imported by W. B. West, with over-wintering fruits attached. The public was not aware of this until 1908.

With the high interest in figs which prevailed at that time, it is not surprising that Rixford plunged into extensive breeding work upon his affiliation with the Government service. Hundreds of his crosses were given to the public for trial. The Maslin seedlings revealed numerous interesting types which invited further study and hybridizing, out of which came such edible varieties as the Rixford, the Eisen, and the Hilgard, and such caprifigs as the Loomis, Newcastle, Mason and Bleasdale. Among the Rixford crosses came the Forbes, Excelsior and Kearney caprifigs.

Another unforseen difficulty in the development of the fig industry had its origin in the fact that mature caprifig trees are necessary to carry the Blastophaga insects through the winter. As a result the newly planted fig orchards failed to set fruit, and by 1908 the situation had become so serious that growers in the San Joaquin Valley threatened to uproot their Smyrna trees. The Maslin orchard again proved a center of interest and Swingle and Rixford conducted negotiations which resulted in the U. S. Department of Agriculture securing a lease on it and for many years furnishing several hundred boxes of caprifigs to growers at cost, thus averting what threatened to be a serious set-back to the industry.

And this while the subject of our sketch was in his early seventies! Need we younger men look further for inspiration?

In "G. P. Rixford—An Appreciation," written for *The California Countryman* two years ago by I. J. Condit, preeminent among the younger generation of California fig investigators, there appears this concluding paragraph:

To those of us who sometimes become alarmed at the increasing number of gray hairs on our brows, a visit and interview with G. P. Rixford emphasizes the fact that love of ones' work and the enthusiastic devotion to an ideal are the best preservatives of youthful energy and the surest antidote against advancing years.

Truly, zestful living has become almost a habit with this veteran plantsman.

# EARLESSNESS IN KARAKUL SHEEP

JAY L. LUSH
*Texas Agricultural Experiment Station*

**THREE EAR TYPES COMPARED**

**Figure 4**

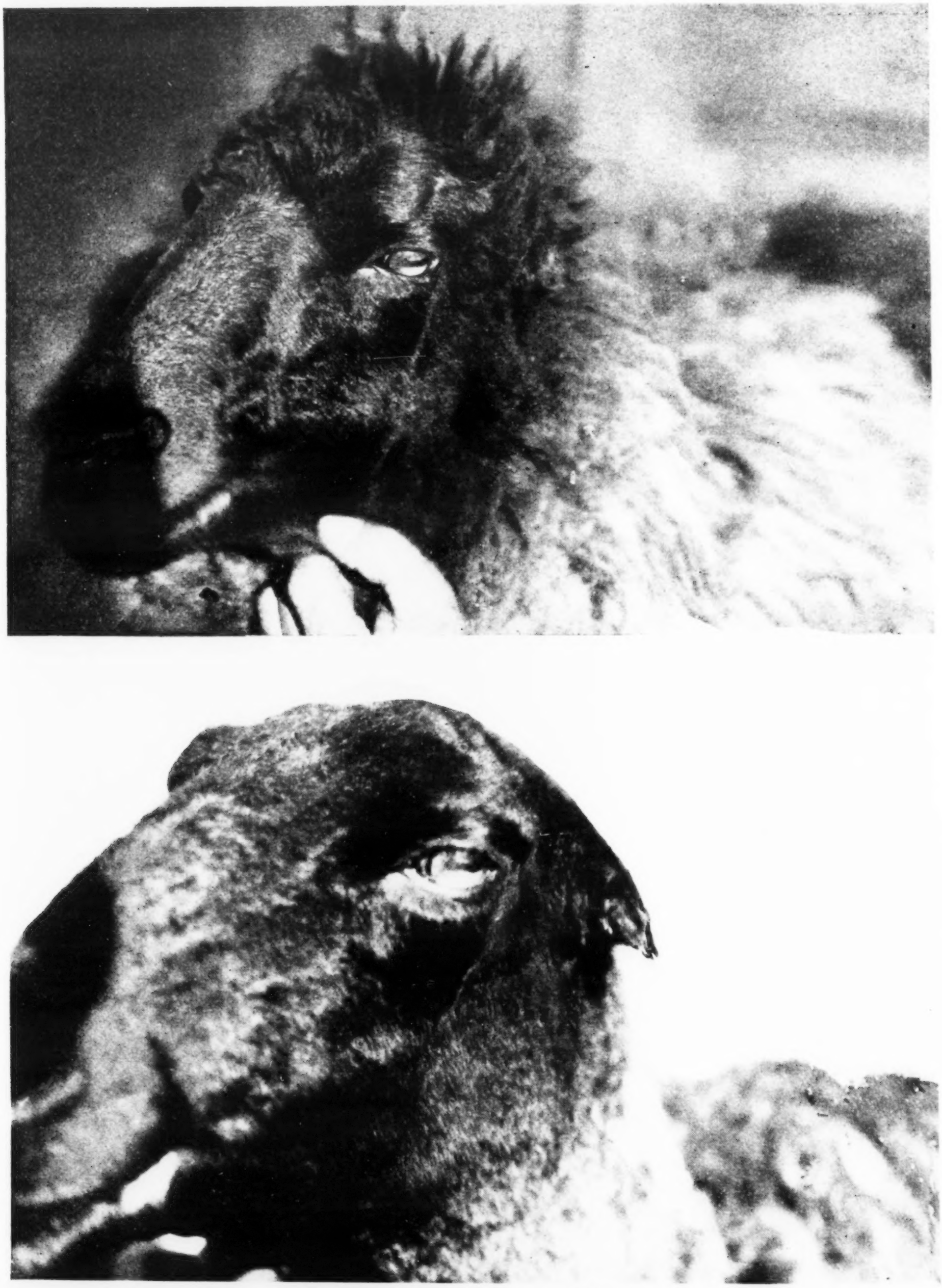
Long-eared, short-eared and "earless" Karakul ewes, showing three degrees of ear development. The rudimentary ear of the "earless" sheep does not extend beyond the fleece.

THE Texas Station maintained a small flock of Karakul sheep from 1915 until 1929 at Substation No. 7, near Spur, primarily to get first-hand information about the possibilities of this breed for fur production.* In making systematic descriptions of the individuals it was noticed that there was a great variation in the length of the ears. The ears seemed to fall into three rather distinct classes on the basis of outward appearance and notes of this were made for a number of years. The flock has now been discontinued and the findings in regard to the inheritance of ear length are presented herewith.

Ears of the shortest class are not visible when the sheep is carrying a fleece of much more than two months' growth, but when the sheep has just been shorn they can be seen easily. On the four sheep measured in this class the extreme lengths from the side of the head to the tip of the ear were 2.4 cm. and 5.0 cm., with an average of 3.5 cm. There was a very sharp natural division between this class and those with ears of medium length. In no case was there doubt about the classification of these extremely short-eared or "earless" sheep. Figure 5 shows "earless" sheep shorn and in full fleece.

The ears of the medium class were much more variable in length and also in shape. We are calling them "short" ears. Typically they were thickened and rather pointed, the edges being grown together farther out toward the tip of the ear than is usual with the mutton breeds of sheep. Some, however, had rather flat broad ends and on several occasions it was doubtful whether a sheep of this kind should be classified

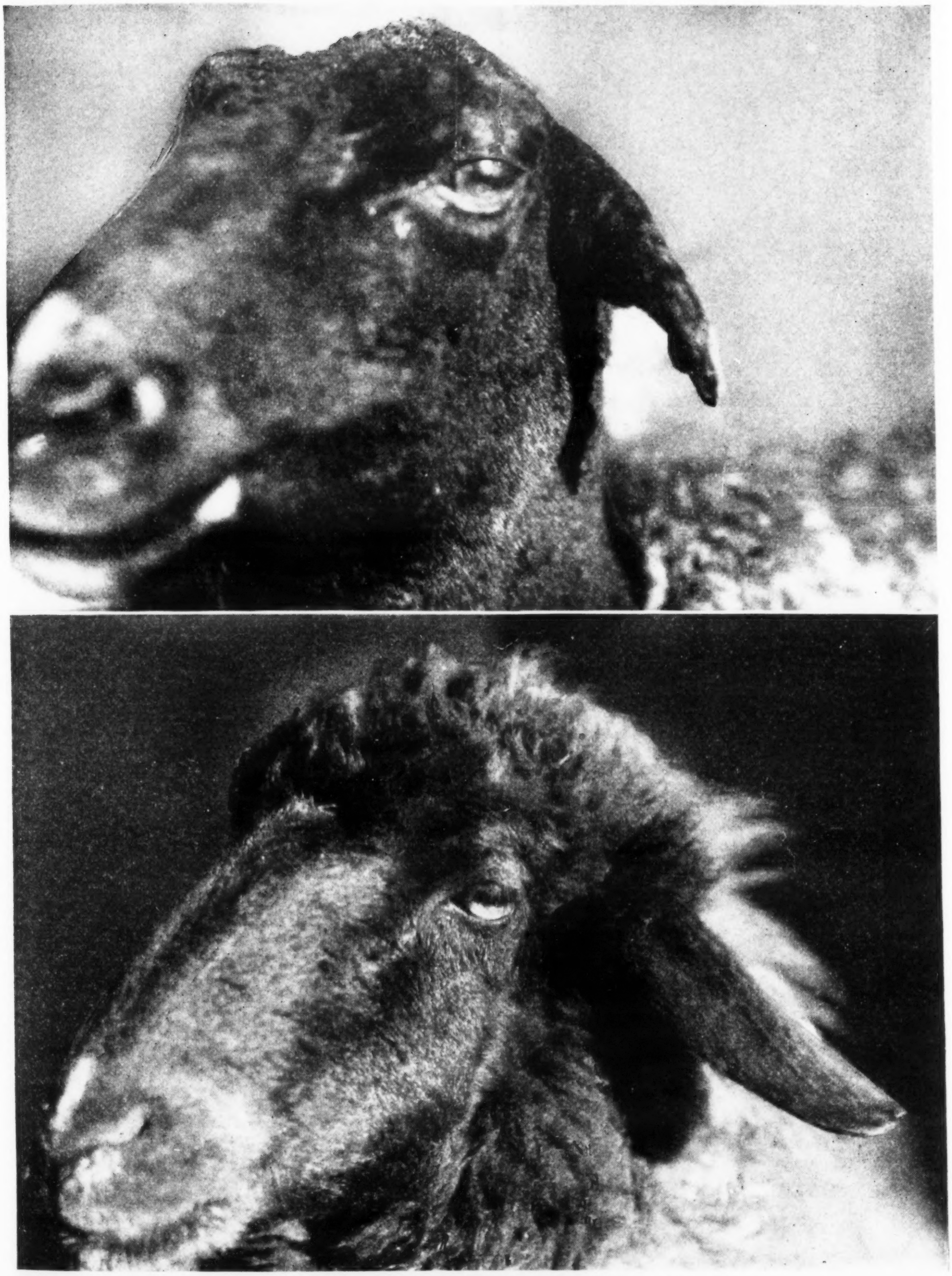
*R. E. Dickson, C. M. Hubbard, R. A. Brewer, J. H. Jones and W. E. Flint were in charge of these sheep and made the collection of these notes possible.



"EARLESS" KARAKUL SHEEP

**Figure 5**

Earless ewes, in full fleece and newly shorn, showing development of rudimentary ear. This peculiarity is inherited, apparently in a Mendelian manner but without dominance.



**SHORT-EARED AND LONG-EARED EWES**

**Figure 6**

The short-eared condition is due to the "earless" gene in the heterozygous condition. Long ear is not completely dominant, and earlessness "shows through" to the extent of making the ear about a third shorter than in the homozygous long-eared sheep.

as "short-eared" or "long-eared." The extreme lengths among the nineteen measured were 7.4 cm. (on a lamb not yet fully grown) and 14.4 cm. (on a sheep marked doubtful as to ear classification at the time the measurement was made). The extreme length on a sheep certainly classified correctly was 12.1 cm. The average of the nineteen was 10.2 cm., and if the doubtful one is omitted the average of the remaining eighteen was 10.0 cm. Figure 6 shows the "short" ear. Figure 8 shows for comparison the normal ear of a Rambouillet wether.

The ears of the "long-eared" sheep were all very broad and flat at the ends and resembled the ears of Angora goats more than they did those of the mutton breeds of sheep. Six were measured, among which the extreme lengths were 13.9 cm. (on a lamb not yet fully grown) and 20.5 cm. The shortest "long" ear measured on a mature sheep was 15.4 cm. The average length of the six measured was 17.0 cm. Figures 6 and 7 show the "long" ear. Figure 4 shows the three types of ears side by side.

Notes as to length of ears were not made on all of the sheep in the early years of the experiment. The total progeny of all matings where the ear length of both parents was recorded was as follows:

1. Long × long = 3 long
2. Long × short = 7 long and 9 short
3. Long × earless = 2 short
4. Short × short = 4 long, 13 short and 5 earless
5. Short × earless = 1 long, 5 short and 1 earless

The mating of earless × earless was not made. With the exception of mating No. 5, the results conform almost perfectly to the hypothesis of Ritzman[1] that this character is determined by a single pair of Mendelian factors of which the homozygous conditions produce the "long" and "earless" types, while the heterozygous condition produces the "short" ears. Mating No. 5 was expected to produce equal numbers of short and earless lambs. The unexpected long-eared lamb was described only from the dried skin and there was a little more possibility for mistake in classification than if it had been described alive. However, its ears were unmistakably broad and flat at the tip, which was unusual for short-eared sheep. Only one ram (a short-eared one) was used that year and there can hardly be any question of mistake in paternity. The putative dam was earless and there is no other reason to think that any mistake was made in ascribing this lamb to her than that it does not agree with the genetic theory of the inheritance of ear length! Mating No. 5 also produced a high ratio of short to earless lambs, but this is well within the limits of experimental error. Wriedt[3] found Ritzman's explanation satisfactory for the inheritance of earlessness and short ears in sheep from widely scattered regions in Norway. Wassin[1] finds the same explanation entirely satisfactory for differences in ear length found in many flocks widely scattered over Russia, but much more frequent in flocks in the Caucasus and regions eastward. He prefers to believe in a single origin of the gene modifying ear length at a very remote period and that a study of its present distribution and frequency would fur-

**NORMAL EAR DEVELOPMENT**

**Figure 7**

Showing the broad tip characteristic of the Karakul ear. Ears of European breeds of sheep tend to be more pointed.

**NORMAL EAR**
**Figure 8**

Ear of Rambouillet wether, for comparison with ear-type of Karakul fur sheep discussed in this article.

**OUTGROWTH ON EAR**
**Figure 9**

Fleshy outgrowth on top of ear. In Turkestan this peculiarity is widespread, and it is said to be recessive. In Texas it is hereditary, but the manner of inheritance is undetermined.

nish useful evidence as to the ancestral origins and migrations of present-day races. Wassin also reports what appears to be the same character in a herd of goats and wonders whether this may not have been the result of crossings with sheep, although admitting that no unmistakable case of progeny being produced from the matings of sheep and goats has yet been reported.

Since the sheep in our flock were Karakuls, it seems quite likely that the gene modifying ear length was introduced with the foundation stock which originally came from the very same part of the world where Wassin reports this earlessness to be quite frequent. However, it seems as easy to believe that this character arose by seperate mutation in the cases described by Ritzman and Wriedt as it does to believe that it had been transmitted in an unbroken line of descent from ancestors which originally came from central

Asia. The wide geographical separation of the cases, the distinct unlikeness of the sheep in other respects, and the absence of earlier reports of this peculiarity, all speak against the hypothesis of descent from a single original mutation, although of course not disproving it utterly.

In other Karakul sheep in Texas but not in the Station flock, we have also noticed on the tops of the ears of some sheep the fleshy outgrowths shown by Wassin in his Figure 5 under the name of "Hautauswuchs (Ohrringe)". Wassin states that it is a recessive character, very widespread in Turkestan. In the Texas flock where it was noticed, the owner of the flock told us it occurred only in certain families, which would indicate an hereditary basis, but no numbers or ratios from different types of matings were secured. We presume that it is identical with the characteristic described by Wassin. Figure 8 shows an ear of this type seen by us.

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## The Sixth International Genetics Congress

THE Sixth International Genetics Congress in 1932 is the second of these events to be held in America. Its organization has been under way during the last few months, and considerable progress has been made in preparation of the preliminary plans. The permanent committee, appointed at the last Congress, in Berlin, has elected the officers and Council of the Sixth Congress as follows:

**President**

T. H. Morgan

**Honorary Vice-Presidents**

E. von Tschermack-Seysenegg, Austria.
V. Gregoire, Belgium.
A. H. R. Buller, Canada.
O. Winge, Denmark.
H. Federley, Finland.
L. Cuenot, France.
C. Correns, Germany.
J. B. S. Haldane, Great Britain.
H. de Vries, Holland.
P. Enriques, Italy.
T. Tanaka, Japan.
L. Cockayne, New Zealand.
L. L. Mohr, Norway.
E. Malinowski, Poland.
N. Vavilov, Russia.
A. Salueta, Spain
H. Nilsson-Ehle, Sweden.
A. Ernst, Switzerland.

**Executive Council**

C. C. Little, Chairman of Executive Council and Secretary General of Congress. Address: Bar Harbor, Maine.

C. B. Davenport, Secretary of Council.

R. C. Cook, Treasurer.

L. C. Dunn, Chairman o fTransportation Committee.

E. M. East, Chairman of Program Committee.

R. A. Emerson, Chairman of Local Committee.

D. F. Jones, Chairman of Publications Committee.

E. C. MacDowell, Chairman of Exhibits Committee.

C. McA. Pyle, Chairman of Finance Committee.

The first meeting of the Council was held in New York on December 28, and three other meetings have been held since. The Congress will convene at Ithaca, N. Y., on August 24, 1932, lasting until August 31. Membership dues to the Congress for those joining at once are $10.00. This includes the printed proceedings of the Congress, and may be paid in two installments of $5.00 with the application and $5.00 in 1931. Other classes of memberships are: Institutional members at $100, Supporting members at $100 to $1,000, and patrons, those who contribute $1,000 or over.

It is planned to make the Congress broad in scope, and to feature the interrelationships between genetics and related sciences—biochemistry, biophysics, and physiology, etc. A special feature will be the exhibits.

# HUNTINGTON'S CHOREA

PAUL POPENOE
*Pasadena, California*
and
KATE BROUSSEAU
*Los Angeles, California*

IN the seventeenth century immigration to the North American colonies were half a dozen English settlers, three of them apparently brothers, who carried the genes of one of the most serious of nervous diseases, a chorea which usually does not make its appearance until adult life, but quickly disables the victim when it does appear, and cannot be alleviated by any known remedy.

The affection made itself known in the descendants of these persons and soon became recognized as a hereditary malady, in the parts of Connecticut and New York where they lived. It was particularly common in the eastern end of Long Island and was observed by two family physicians of the old type, father and son, whose combined experience there covered a period of seventy-eight years. It was left to the grandson, however, who also took up medicine but moved to Pomeroy, Ohio, to describe this in print.[4] His name thereby became attached to it and it is still known as Huntington's Chorea.

Four elements have been mentioned as characterizing it: (1) persistent tremors which (2) usually make their appearance in middle life, (3) grow progressively worse, and (4) are accompanied by mental deterioration. None of these elements is invariable, however.

While the hereditary nature of the affection had long been recognized, it was first worked out in detail by Charles B. Davenport,[2] on the basis of elaborate pedigree charts covering some 4,000 individuals, which had been brought together under his direction by Elizabeth Muncey. Dr. Davenport showed that the affection behaves beyond question as a simple dominant in these families, all of which are possibly related to each other. It was also found to be a simple dominant in a study of all the cases that could be discovered in Bavaria;[3] this characteristic may, therefore, be taken as a general one.

### A California Case

It is equally shown in the accompanying pedigree which one of us (K. B.) traced in California, beginning with a young woman who had been committed at the age of twenty-five to one of the state hospitals.

The onset in her case was shortly before the age of eighteen; however, she was able to enter a normal school in another state and make good progress in her studies until a year later mental deterioration began to set in. When examined by Dr. Brousseau she tested 7 years, 11 months on the Stanford Binet scale, but this was an inadequate test due to her mental deterioration. She had some hallucinations and constant delusions with a strong erotic trend, bearing particularly on her supposed approaching marriage—first to a boy she had known in high school, then to a wealthy man who was the offspring of her imagination.

She came of an intelligent family, originally from the state of New York, and while it was impossible to connect her lineage with any of the pedigrees that Drs. Davenport and Muncey studied, one naturally suspects that it goes back to the same origin.

Not all of the Huntington's Chorea in the United States is derived from this Atlantic Coast group, however, for it shows up from time to time in other stocks. It is one of the less common nervous diseases: in 1922, 26 men and 24 women were admitted for the first

time to American psychopathic hospitals, with the diagnosis of Huntington's Chorea, and on January 1, 1923, there were in all such hospitals of the United States a total of 146 men and 171 women afflicted with it.[4]

Perhaps there are as many cases outside the state hospitals as in them. Many of the families in which the affection occurs are relatively well-to-do and able to keep a patient at home, particularly if his mental deterioration is not of a nature to make much trouble. Those whom the public hospitals receive are in all likelihood either the poorest or the most disturbed cases.

The figures indicate that there is no sex-discrimination on the part of the disease, and this has been the observation of all students, being shown with unexpected precision in our own chart covering six generations (in part), in which four men and four women are affected.

### Different Types of Chorea

There are various types of chorea apart from that to which the name of Dr. Huntington has been attached. In this respect the situation recalls epilepsy, which refers to particular bodily reactions, i. e., convulsions, accompanied by loss of consciousness. Convulsions may be brought about in a variety of different ways, all of which presumably pull the trigger of the same bodily mechanism.

The ordinary chorea of childhood seems to affect girls more than boys, and is generally less severe in its symptoms. Huntington's chorea can be distinguished from others, within limits, by the character of the bodily movements, which are coarse and grimacing, and less localized than in the commoner chorea of childhood. Comparatively violent jerks of the legs produce a difficult and grotesque gait. The speech is usually sluggish and indistinct; but a peculiar twitching of the tongue that is usually present in childhood chorea is not often seen in Huntington's chorea.

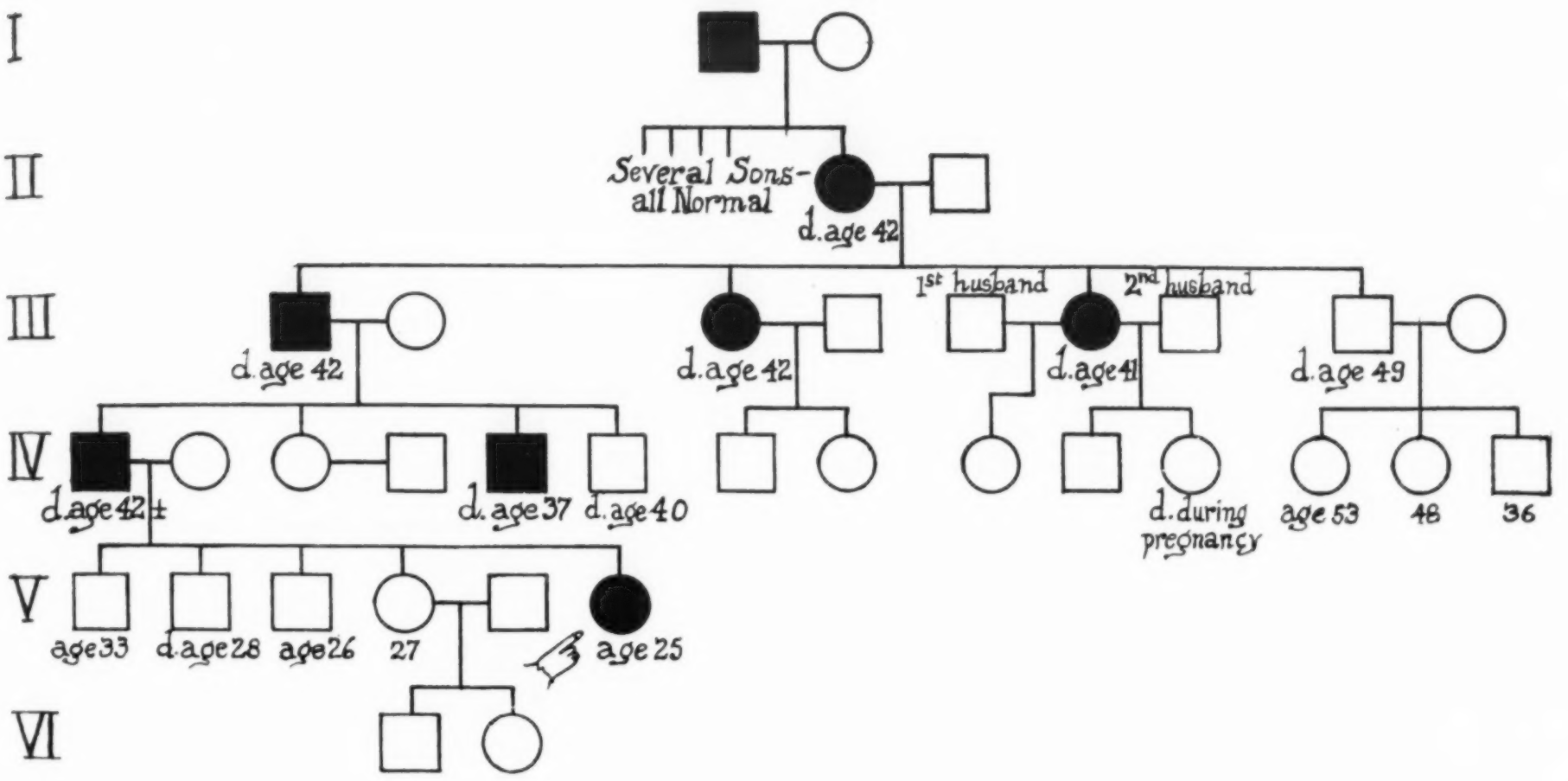
Here, again, the mechanism involved is evidently one that can be set into action in a number of different ways. Anything that affects the nerve cells of a certain part of the brain will produce somewhat comparable symptoms. The cause of childhood chorea is generally supposed to be an infection (Streptococcus or other) that influences a certain group of nerve cells; while these same cells may be influenced by genetic factors at another period.

Most recent attempts to determine the basis of this affection have centered on the corpus striatum, a part of the brain which lies on the inside, underneath the cerebral cortex. It consists of both gray matter and white matter, and contains several parts with different functions—all of them, however, very little understood.

### Changes In the Brain

Examinations of the brains of patients who have died with Huntington's Chorea agree[6] in showing a reduction in the size of the whole organ. The gray matter of the cerebrum seems in most cases not to be greatly changed either in quantity or in quality, but the amount of white matter is much reduced, the average loss amounting to more than 150 gm., as compared with a normal brain. The corpus striatum shows a still greater decrease in volume, being reduced to about one-half of normal. This shrinkage in bulk is accompanied by a great loss of nerve cells in two parts of the corpus, namely, the caudate nucleus and the putamen; the number of nerve cells in a third part, the globus pallidus, seems, on the contrary, to be unaffected. No other constant changes have been found in other portions of the nervous system.

The best guess at present, therefore, is that Huntington's Chorea is the result of a degenerative change in the brain, affecting principally some of the parts of the corpus striatum; that this change is brought about by the action of a single gene which has at some time in the past mutated from a normal state; and that this germinal difference is one which does not make its action felt, in most instances, until relatively




**FIVE GENERATIONS OF HUNTINGTONS CHOREA**
**Figure 10**

Many other family charts of Huntington's Chorea have been published, which agree with this one in indicating that this serious form of mental disease is inherited as a mendelian dominant character.

late in the life of the individual, in this respect resembling such germinal changes as those that produce pattern baldness or defective hearing (otosclerosis) in middle life.[6] While all the genes in the cell probably produce an effect of some kind at all times after the initial fertilization, the principal or only effect so far known is occasionally one that thus manifests itself only several decades after birth.

The corpus striatum has been thought by some investigators to have a steadying or inhibiting function; its degeneration would simply remove this function and the individual would thereby revert to a condition like that of the new-born baby, whose uncontrolled and uncertain movements are ascribed in part to the fact that the fibers of the corpus are not yet medullated and hence this part of the brain is inactive.[7] If this view could be established, it would be easy to suppose that Huntington's Chorea represents merely an arrest of development of this part of the brain; the infantile condition is never outgrown. All the facts tell against it, however, for microscopic examination shows a brain which is degenerating from a more normal condition, not one that has failed to develop normally. In other words, Huntington's Chorea is clearly a variety of mental and nervous *disease*, and not an example of congenital *deficiency*. Moreover, the victim shows no signs in childhood (save in very rare cases) of the fact that he is marked out for a breakdown later. All the evidence, then, indicates that the single difference in the germ-plasm which produces Huntington's Chorea is one that makes this effect felt late in life.

### Chorea In Twins

The strictly hereditary nature of the affection is demonstrated not only by the pedigree charts, but also by the study of twins. If these are unlike, one of them may be affected, the other quite normal, as in a family which showed three generations of this malady.[8] Here twins were born, a boy and a girl; the former was quite unaffected but the latter began to show symptoms of it from the age of four. On the other

hand, identical twins are both affected, as in the case described to us by Dr. R. B. Kershaw of Agnew's State Hospital, California. The patients were twin brothers, aged sixty, who had formerly been under his observation in the state hospital at Yankton, South Dakota. They were on the same ward but paid no attention to each other as a rule; never spoke to or looked at each other. If one got into difficulty, however, the other would at once rush to his rescue.

Since marriage in which both partners are affected will be exceptional, the commonest mating will be that in which one partner has chorea, the other is normal. Modifying genes play such an important part that every family may properly be said to have its own type of Huntington's Chorea; but Dr. Davenport pointed out that each of the four principal components is susceptible to change, so that in one family the affected often show dementia without the tremor; in another the tremor is accompanied by very little dementia; in a third the onset is unusually early (present at birth in two instances); in a fourth it appears in middle life but is not progressive. Innumerable other nervous and physical affections are found in the families of choreic patients: in some instances these are doubtless intercurrent and simply represent a coincidence of two or more unrelated germinal differences;[9] in other instances they must represent the action of modifying genes along with that of the chorea. Thus the dementia might be increased or diminished accordingly as the degenerative processes in the brain affected the cortex in greater or less degree.

In matings of the type mentioned (heterozygote × normal, DR × RR) half of the offspring will be affected, on the average, and this finding is confirmed in chart after chart with an accuracy that is rare in studies of human heredity.* Early death doubtless often prevents the appearance of chorea in an individual who is therefore wrongly listed as normal; for while onset is in extreme cases at birth, in other extreme cases it has not appeared until the seventh or eighth decade. Dr. Davenport found only five cases out of 962 which he studied (521 males and 441 females) in which an individual who was choreic did not have a choreic parent. There is no difficulty in supposing in these instances (all of which were in choreic families) that one of the parents actually carried the gene, but that its appearance was masked by other influences, or that death occurred before the onset of the symptoms.

### The Eugenic Aspect

Since onset so often occurs after the age of marriage, the problem of the apparently sound offspring of an affected parent is a grave one. Shall they marry because apparently sound, but knowing that the affection may make its appearance a few years later? It is greatly to be desired that some means of detecting the presence of the gene in childhood, or at least soon after adolescence, be devised. Presumably it is active from the time of conception, even

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*A Canadian family of English extraction which may very well represent another offshoot of the same stock that contributed the original American carriers of this chorea, is reported[10] by John W. MacArthur, who found 33 choreic to 12 normal children and believes that this represents a 3:1 ratio, not the 1:1 which has been assumed to prevail in other studies. He suggests that "possibly this type of chorea will prove to be represented in the germ plasm of some families by two more or less independent dominant genetic factors." There is no reason to suppose *a priori* that chorea will be inherited in the same way in every family; but certainly the hypothesis that it is due to two independent dominant genes will not suffice to raise the ratio of affected to normal offspring. It would merely tend to make chorea rarer in these families. If the excess of affected is not due to the small numbers available, it is probable that some of the matings were not DR × RR but DR × DR in which one partner had, because of age or other causes, not manifested the affection. That some inbreeding would take place, even though unknown to the partners, is suggested by the fact that "the choreic branch of the family has remained concentrated near the sight of the original settlement in Southern Ontario."

though the activity may not rise above a certain threshold, and produce disastrous results, until after many years. It is conceivable that sufficiently delicate tests of motor control might show its presence even before it makes its appearance as an incurable affliction; but none is yet available, and the choreic are often particularly vigorous and attractive children. Since it is at least an even chance that the offspring of one choreic parent will have chorea, and since the disease is of such a severe character, it does not seem too much like a counsel of perfection to suggest that these offspring should not marry unless conditions are such that a breakdown of the individual would not leave the family financially dependent; and that in any case, marriage should occur only when the circumstances are fully understood by the other partner, the undesirability of children agreed upon, and the sterilization of one or the other has taken place. In this way the genes of Huntington's Chorea would gradually be eliminated from the population.

It might be supposed that self-interest if not altruism would lead to such a solution naturally, but that does not seem to be the case. Dr. Davenport found little or no evidence of abstention from marriage or diminished fecundity in the great pedigrees which he examined. A study[11] of families of patients in the Kalamazoo (Michigan) state hospital brought to light 218 affected individuals of whom only 35 had remained single. In our own small fragment of a pedigree chart, most of the affected individuals married.

Ethically, it is doubtful whether any human being has a right to give the genes of Huntington's Chorea, hemophilia, or similar serious diseases circulation; and for its own protection society has certainly the right to prevent such perpetuation of undesirable genes.[12]

### The Interests of Society

It is true, here as in other cases, that such a course as that recommended would prevent the birth of a number of normal children, perhaps some superior ones. But the birth of normal and superior children in immense numbers is being prevented daily in a multiplicity of ways—particularly by contraception. The only question to be argued, then, is whether the course above outlined would prevent the birth of an unduly large number of normal or superior children—larger than the average, or large enough to outbalance the inconveniences resulting from the presence of such a disease as Huntington's Chorea in the population. Many persons who are familiar with the results of the present policy: who have watched the individual suffering; have noted the frequency of alcoholism and suicide in these stocks; have seen families left dependent and in misery; will believe that society could afford to pay a much higher price for the elimination of this defect than it is likely to have to pay.

It happens that the families which are best known in the United States for the presence of Huntington's Chorea are intelligent, superior families, so that the question is put clearly. Dr. Davenport has answered it with equal clearness, in urging that the immigration of persons with such inheritable affections as Huntington's Chorea could be prevented if some knowledge of the ancestry of every immigrant were required. Had the three brothers above mentioned as original immigrants been excluded because one of their parents was choreic, he says: "We would have lost two leading educators, a surgeon or two, two state senators, two or three state assemblymen, several ministers, and 900 cases of one of the most dreadful diseases that man is liable to, that does not kill quickly like cancer or lead rapidly to complete helplessness like paresis, but produces individuals who for half a century may know no waking hour free from forced movements, often of a violent character, and in whom often the mental functions, one by one, deteriorate."

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12. GOSNEY, E. S., and PAUL POPENOE. *Sterilization for human betterment.* New York, 1929.

## Books Received

*BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the Journal will be reviewed in later numbers.*

WHAT IS EUGENICS? *by* MAJOR LEONARD DARWIN. Pp. 88. 17 Chapters. Price $1.00. Galton Publishing Co., New York, 1929.

The distinguished President of the British Eugenics Education Society has prepared an excellent short primer of Eugenics, of which an American edition has just been published.

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PLANT BIOLOGY: An outline of the principles Underlying Plant Activity and Structure, *by* H. HODWIN, M.A., Ph.D., Fellow of Clare College and Demonstrator in Botany in the University of Cambridge. "A text-book for first-year medical students, and for biological students of similar status. The author has particularly emphasized the physiological point of view and the physico-chemical background of plant-life." Pp. 265. 14 Chapters. Price $2.90. Cambridge University Press, Cambridge, 1930.

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THE MILLENNIUM AND MEDICAL SCIENCE, *by* DAVID NICHOLAS SCHAFFER, M. D. Pp. 370. 20 Chapters. Price $2.00. Wilbur Needham, Evanston, Illinois, 1924.

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LABORATORY EXERCISES IN ZOOLOGY: A Practical Student's Manual for Classes in Animal Biology. *By* WILLIAM MORTON BARROWS Sc.D. Pp. 103. 2 Parts: 30 Exercises and 25 Projects. World Book Company, Yonkers-on-Hudson, N. Y., 1930.

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IS SEX NECESSARY, OR Why You Feel the Way You Do, *by* JAMES G. THURBER and E. B. WHITE. Pp. 297. 8 Chapters and glossery. Price $2.50.

Two New York journalists having some fun with sex pseudo-science literature. The reader has his share of the fun, too. As an investment in chuckles it is excellent.

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FORMES GRECQUES DE BLE, *by* J. S. PAPADAKIS, Director of L'Agriculture Station d'Amelioration des Plantes a Salonique. Pp. 61. 22 pages of illustrations. Price $2.00. Agriculture Station d'Amelioration des Plantes, Salonique, 1929.

Greek forms of wheat, well illustrated.

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ALBINISM IN DOGS, *by* KARL PEARSON and C. H. USHER. From *Biometrika*, a Journal for the Statistical Study of Biological Problems. Vol. XXI. Parts 1 to 4. Pp. 30. 8 Plates, 2 Pedigree Charts. University Press, Cambridge, 1929.

# RADIUM EXPERIMENTS WITH DATURA

## I. The Identification and Transmission of Lethals of Pollen-Tube Growth in $F_1$'s from Radium-Treated Parents*

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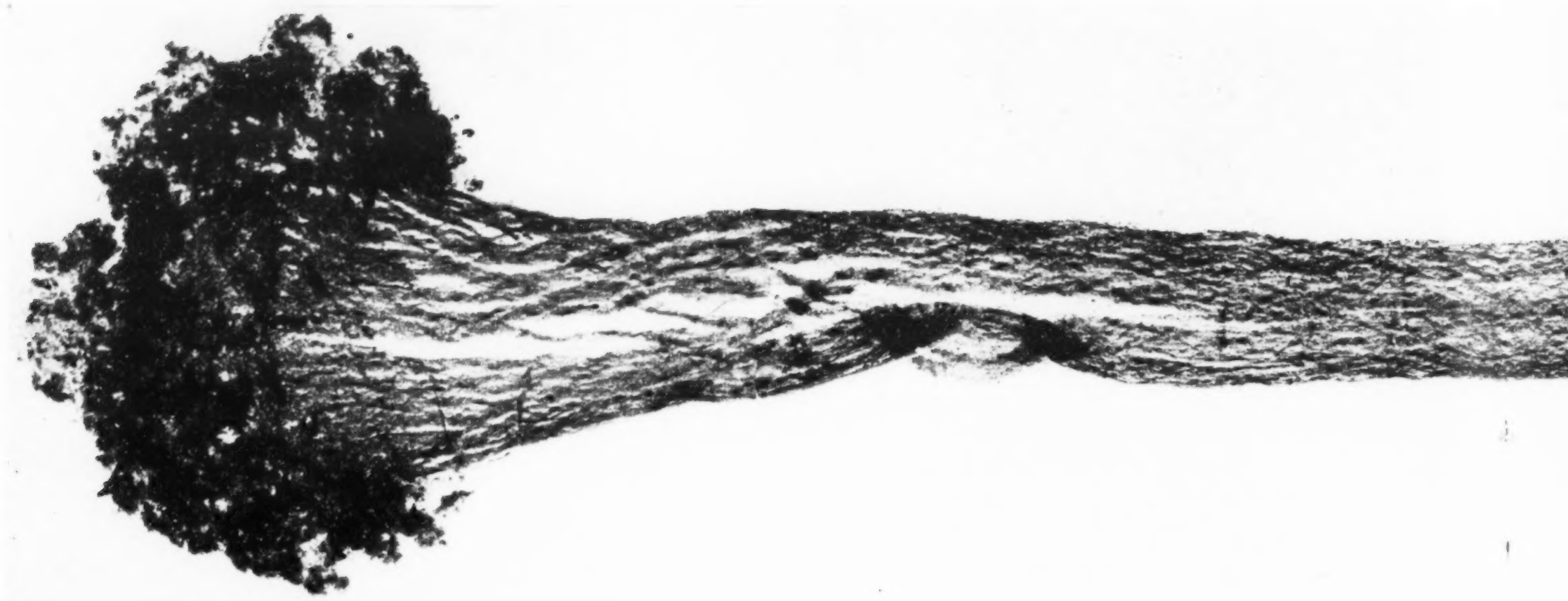
IN 1921 Gager and Blakeslee treated some flower buds of Datura with radium emanation which resulted in the production of many $(2n+1)$ types[4]. These included one very unusual chromosomal type Nubbin.[1] Two gene mutants segregated out in the $F_2$ from 18 $F_1$ plants tested. These results made it seem advisable to continue radium treatments of Datura with the hope of obtaining additional genes. Our investigations were further stimulated by the discoveries of Muller in successfully inducing gene mutations in Drosophila by the use of X-rays[5]. Since it was our desire to increase our stock of new genes, the renewed experimental procedure was planned in such a way that it would not be likely to result in $(2n+1)$ types, in the hope that new genes might be more easily and immediately recognizable in segregation from $2n$ plants. We selected the pollen and pollen tubes as the stage in the life cycle to be treated with radium, because by the treatment of these haploid stages we would obtain treatment for only one of the group of chromosomes in the resulting diploid. This method would tend to limit the possibility of nondisjunctions which might be induced if the treatment were given during meiosis. We have found since that somewhat similar results may be obtained from a treatment of our plants in other stages of life history, both with X-rays and with radium.

The experiments which we are here describing were from treatments given in the summer of 1927. Line 1-A plants were used and the treatments were given with radon (radium emanation) by exposing the pollen grains or growing pollen tubes to the agent. Some of the resulting plants, which we are designating as $F_1$ plants, were grown in greenhouse early in 1928, selfed, and their $F_2$ seedlings planted in the garden. A second planting of $F_1$ plants was also made in the garden, so that during the summer of 1928 pollen-tube growth in many field grown and greenhouse $F_1$ plants could be investigated. From most of the $F_1$ plants still growing in the greenhouse small pedigrees of $F_2$ plants were available in the garden. A study of the irregularities observed in pollen-tube growth in this series of plants and the inheritance of these lethal and semi-lethal conditions is the subject of the present paper. An account of the externally visible hereditary changes resulting from this series of treatments including a more detailed account of the new type Sugarloaf translocation, will be described in greater detail elsewhere.

The gametophytes were treated in two stages: (a), the mature pollen grains before pollination, and (b), the pollen tubes growing in the style after pollination. The mature pollen used in method (a) was treated in the laboratory so that the radioactive agent was not brought near the plants which were used as females. In our second method

*This investigation was begun in 1927 under a grant from the Joseph Henry Fund of the National Academy of Science and was continued in 1929 with the additional assistance of a grant from the Committee on the Effects of Radiation on Living Organisms, National Research Council. The following have at various times served as assistants during the progress of these and similar investigations: Lillian Martin, Maribel Loving, Elizabeth Sledge, Frank Normand and C. C. Doak.

We also are greatly indebted to Dr. H. J. Bagg of the Memorial Hospital, New York, for supplying us with the radon used in 1927 and for suggestions concerning the methods of handling radium preparations.



*Burst Pollen Tubes*

**POLLEN TUBES IN STYLE OF DATURA**
**Figure 11**

Enlarged photograph of a stained preparation of a style of normal Datura, pollinated fourteen hours earlier with pollen of plant 27370 (1), an $F_1$ of a radium treated plant, in which half or more of the pollen grains fail to germinate or fail to grow normally. The linear distribution of the forward ends of the pollen tubes is shown plotted in the diagram at the right (Figure 11*A*). The black bars at the left of the graph indicate the 321 ungerminated pollen grains counted on the stigma, which show as black dots in the photograph. The heavy, cross-shaded area below the line in the graph, represents the group of abnormal pollen tubes which can be seen at the left in the style. The group of normal pollen tubes toward the right end of the graph is indicated by the black lines in the photograph.

(b) the radon preparations were fastened along the sides of the style, opposite the growing pollen tubes in order to treat the latter during growth. Here the ovaries and other parts of the flower were not especially protected save for two thicknesses of lead foil surrounding the assemblage and by their greater distance. We cannot claim, therefore, that all of our results in (b) were due to radiation of the pollen tubes, but it is highly probable that they were, since the ovaries were subjected to less than a hundredth part of the intensity of radiation received by the pollen tubes.

The treatment of pollen according to our first method (a) was accomplished by the use of a glass tube of radium emanation usually called radon, of 8.4 millicurie strength for 18 minutes, screened through lead foil .05 mm. thick. The pollen was exposed while still in the unopened anthers in a specially constructed lead holder, and was at an average distance of 1 mm. from the sides of the .7x13.3 mm. sealed glass tube containing the radium emanation. Only 8 mm. of its total length was exposed to the pollen at this close range, as the ends of the radon tube which projected over the holder were at a greater distance and partially shielded from the pollen by the apparatus. We can therefore estimate that about .6 of its radiant energy was effective. The exposure of 18 minutes gave 2.7 millicurie hours as the total dosage emitted by the radon, or 1.6 millicurie hours when calculated for the effective part of the tube, considering that the radon tube extended beyond the anthers and the ends were shielded by the lead holder. This value is for an exposure of the anthers placed parallel to the tube at an average distance of 1 mm., and in the case of the pollen treatment which resulted in plant 27370 (1) the radon was screened through .05 mm. of lead foil. The pollen was also surrounded by the walls of the anthers during treatment.

The pollen tubes (b) were exposed to a much weaker radon tube, and for longer periods. Since the pollen tubes were growing through the field of radiation, they were not at all times ex-

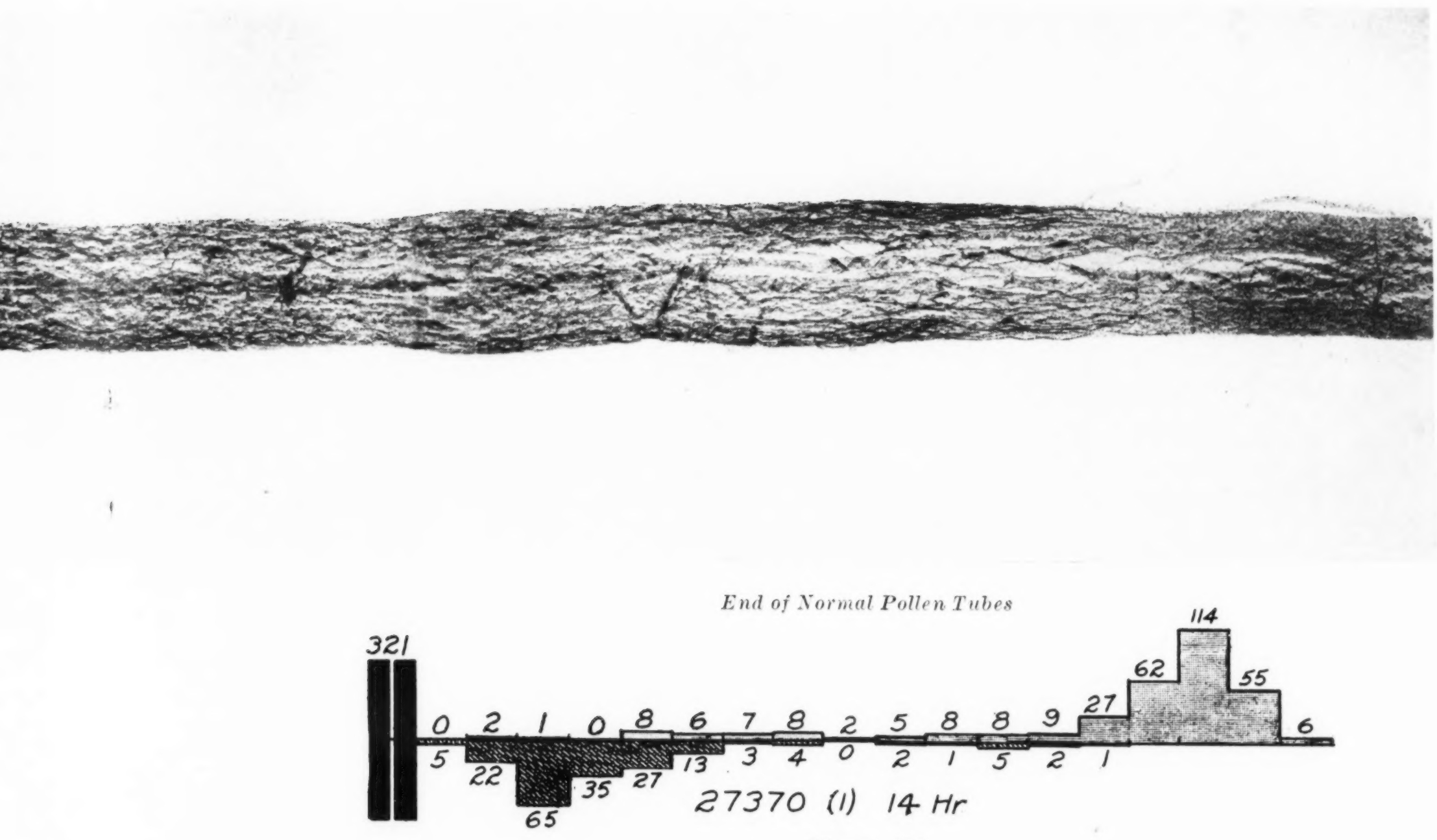



**Figure 11A**

posed to the same intensity of treatment. The exposures extended over several hours through the day, or over night. In one of the successful treatments, the one giving rise to pedigree 27374, concerned in this account, the conditions were as follows: An unscreened radon tube of 1.14 mc. strength was attached to the upper part of the style of a flower which had been pollinated a few minutes before, and left in the garden over night for 14 hours. Since the temperature during treatment averaged 21° C, we estimate that the pollen tubes were growing at the rate of 2.7 mm. per hour and passed through the field of most intense radiation in 7.5 hours. We had previously determined by laboratory tests that this dosage would impede pollen-tube growth only very slightly and would not lead to other immediate abnormalities. The distance of the pollen tubes from the radon was determined by the thickness of the cortex of the style and the proximity of the radon. It was not more than 1 mm. and probably somewhat less, so that the pollen tubes on the side farthest away from the field of radium influence were about 1 mm. from the tube. The ovary was at least 45 mm. from the nearest part of the radiation source and the intensity of radiation received by the pollen tubes during their maximum treatment was therefore several hundred times as great as that received by the more distant ovary.

The seed capsule resulting from the treatment last described was of medium size, but contained only 13 seeds, 10 large seeds and 3 small seeds, plus hundreds of slightly enlarged ovules which had aborted. From the large seeds, 6 $F_1$ plants were grown to maturity in pedigree 27374. These plants were all normal-appearing $2n$ plants which differed in no detectable external detail from untreated plants except that one of these plants, 27374 (1) had 50% shriveled pollen grains. However, plant 27374 (6), the one which we are describing here, had practically none or at least no more shriveled or otherwise abnormal pollen than is found in ordinary $2n$ plants. That the plants should appear normal was to be expected if new genes for which they were heterozygous were all recessive. They were all examined cytologically by Dr. Berg-

**UNGERMINATED POLLEN GRAINS**
**Figure 12**

A dissected portion of a stigma pollinated with 27370 (1) showing many ungerminated pollen grains, some of which have burst or become irregular in shape. Statistics of this test are given below.

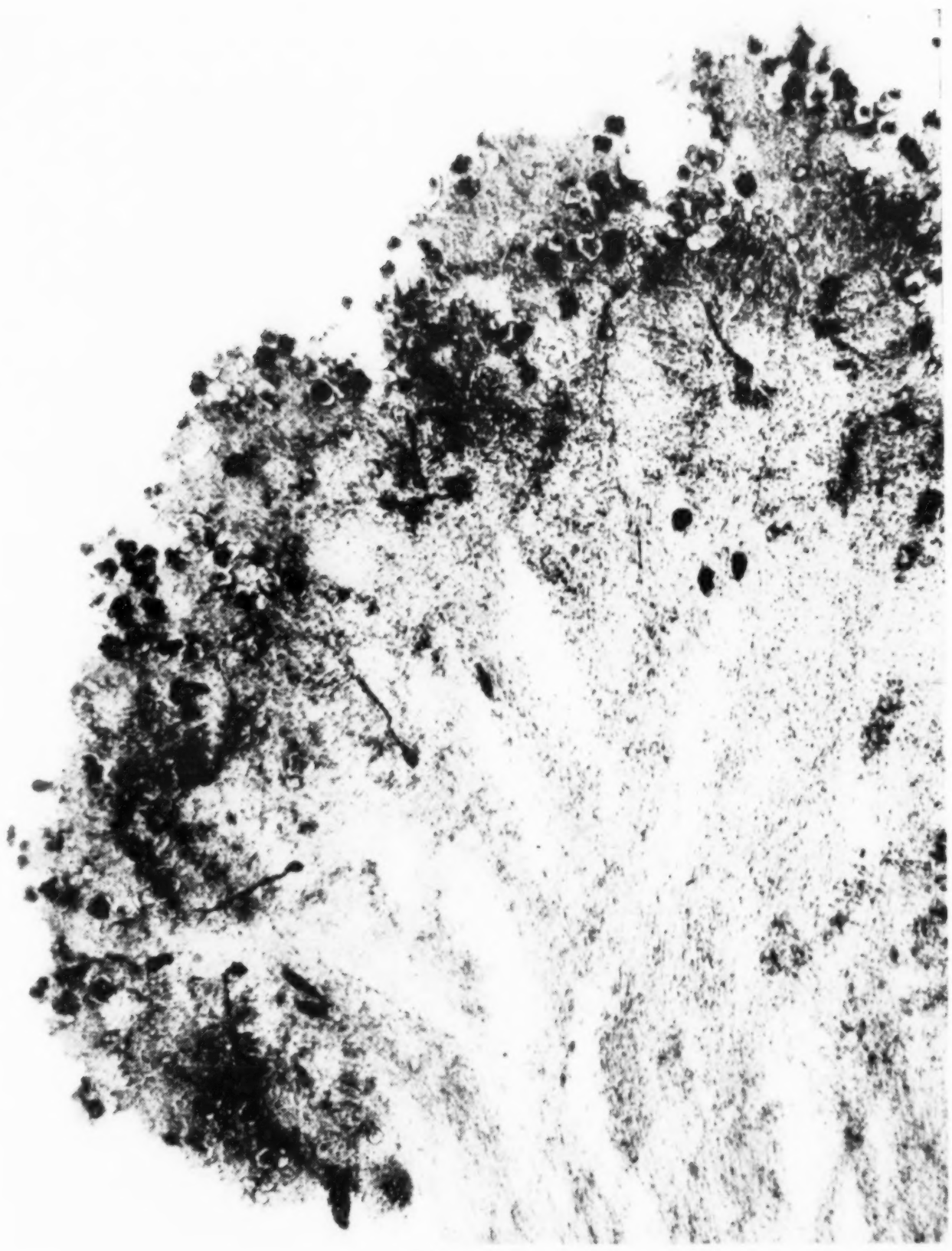


Figure 12

**Figure 12A**

This diagram shows the distribution of the ends of pollen tubes within the style shown above. The tubes are represented as growing from left to right. The vertical bar at the left, represents the ungerminated pollen grains on the stigma, some of which appear as black spots in the photograph at right. Normal appearing pollen tubes are plotted above the datum line (stippled area) and abnormal or burst tubes below (cross hatched). The "steps" represent 2 mm. intervals and the figures represent the numbers of pollen tubes observed.

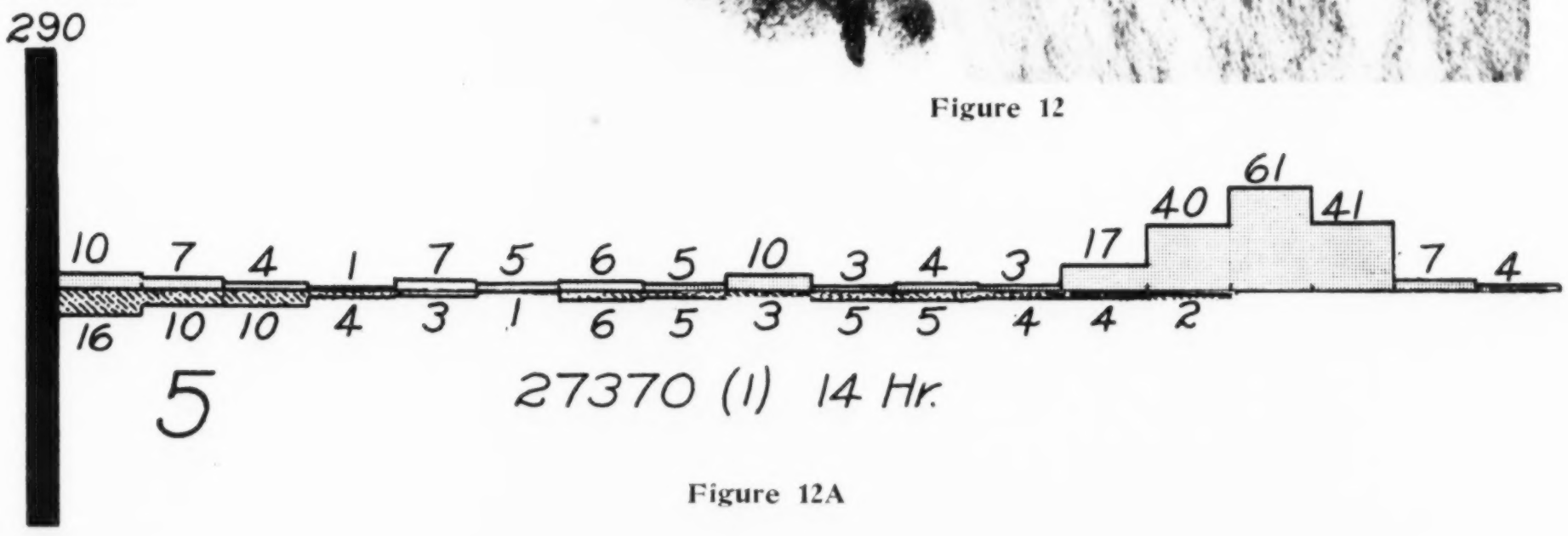



**Figure 12A**

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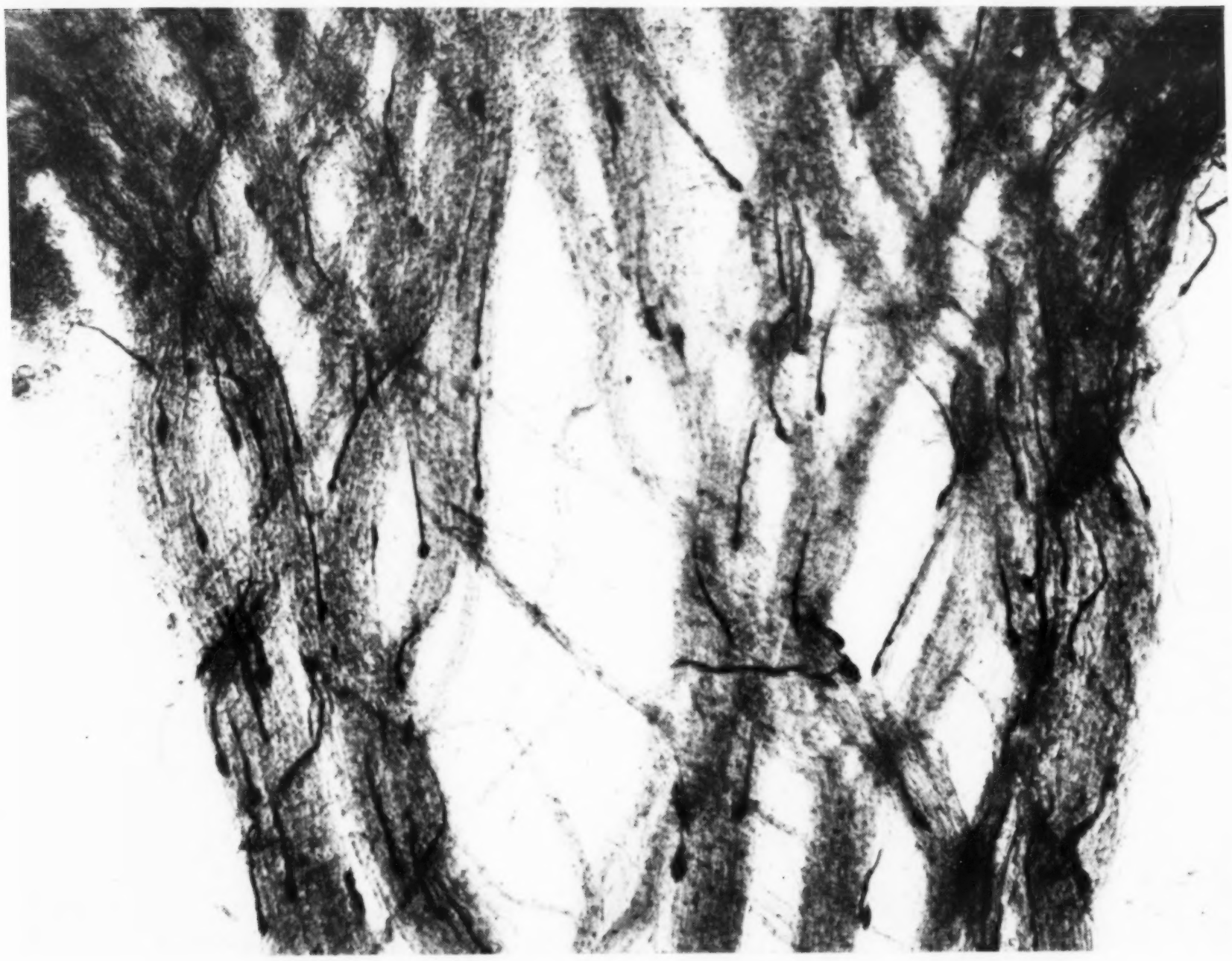
Plant 27370 (1) obtained from the treatment of pollen (a) was likewise normal in appearance and showed upon examination no cytological evidence of chromosomal irregularities during microsporogenesis. However the pollen of this plant was partially abnormal. Many empty pollen grains were found devoid of protoplasmic contents but not shriveled, so that this abnormality was at first overlooked in the routine examination of this plant for "bad pollen." In our study of pollen-tube growth from this plant, the counts were confined to the major fraction of the pollen which had deeply staining contents, appeared otherwise normally matured and might be expected to germinate.

Of course we obtained many other $F_1$ plants from similar treatments, 384



**BURST POLLEN TUBES**
**Figure 13**

Dissected upper portion of a style pollinated with 27370 (1) in which some of the abnormal pollen germinated giving rise to many tubes with swollen or burst ends.

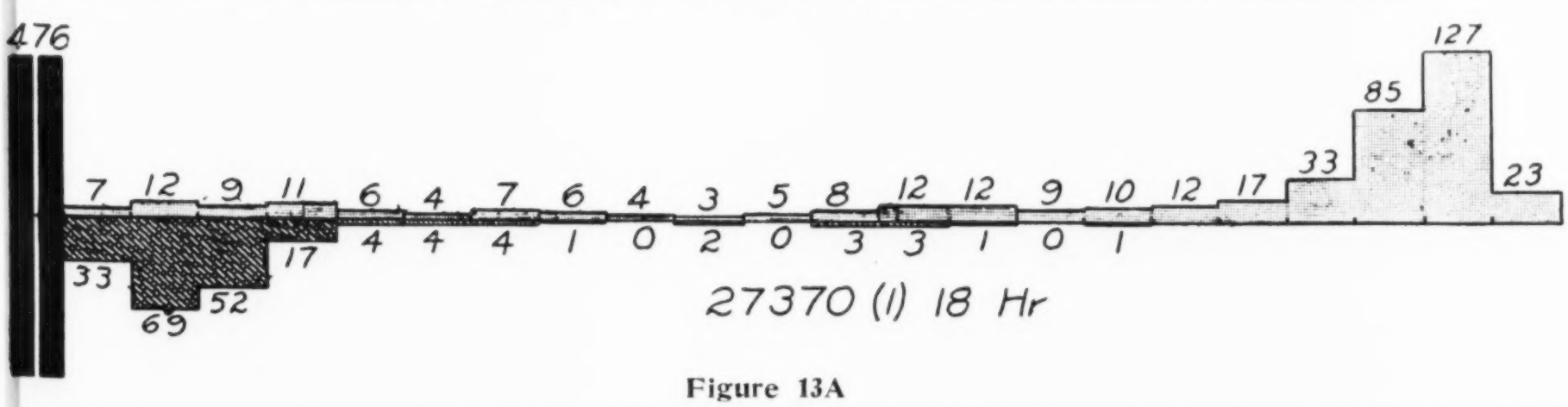
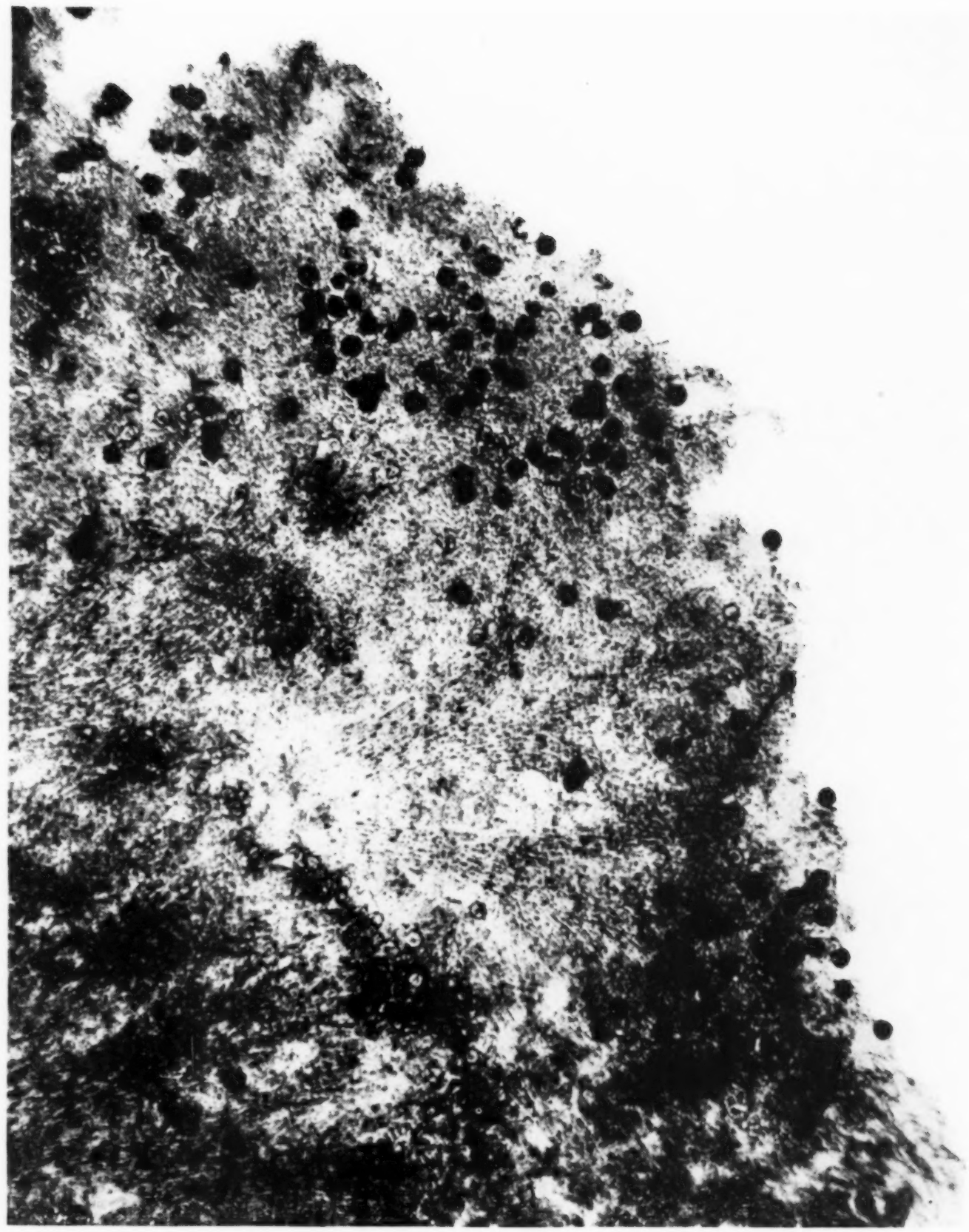



**Figure 13A**

Distribution of pollen grains and tubes in test of 27370 (1), shown in photograph above made for an 18-hour period. The abnormal tubes plotted near the extreme left are shown in the photograph above.

in all, 192 of which were tested by the methods described in this account. In the interest of brevity we have selected only two of the plants showing abnormal pollen-tube growth conditions, from the 48 abnormal $F_1$'s which were found: 27374 (6) and 27370 (1). These were fairly typical of many of the others which indicated abnormalities, and were selected for this description because a fair sample of their respective $F_2$ progenies had been examined for inherited pollen-tube growth conditions. Plant 27373 (3), an $F_1$ resulting from similar treatments but showing no abnormalities in pollen tube growth, together with its $F_2$ progeny is described to serve as a control since we had also made tests of pollen-tube growth in a considerable number of its progeny.

Our methods of testing pollen-tube growth in the $F_1$ and $F_2$ have been described in greater detail elsewhere.[2] The pollen of the plant to be tested was



## NORMAL AND UNGERMINATED POLLEN GRAINS

**Figure 14**

Part of a dissected stigma pollinated with normal untreated pollen showing very few ungerminated pollen grains and many exines, the outer spore coats, from which pollen tubes have grown. Figures 16 and 18 show the statistical distribution of pollen-tube ends from similar tests in $F_1$'s which gave normal pollen tube growth.

**Figure 15**

A part of a dissected stigma pollinated with 270347 (2) an $F_2$ from radium treatment. In this case the ungerminated pollen grains were more rounded and not as irregular as in Fig. 12, and many of

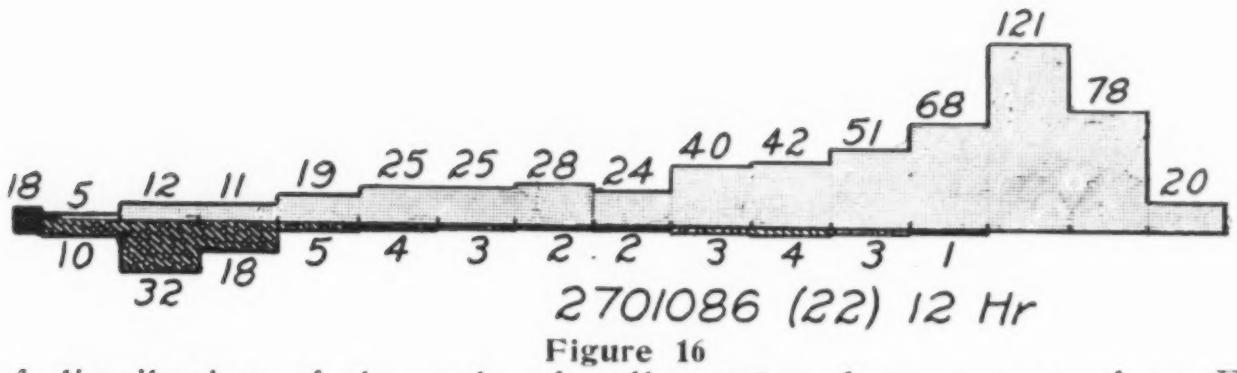



**Figure 16**

Diagram of distribution of the ends of pollen tubes from a test of an $F_2$ 2701086 (22) which showed normal pollen-tube distribution. The gene affecting pollen germination in its parent was not inherited by this plant. From a 12-hour test.

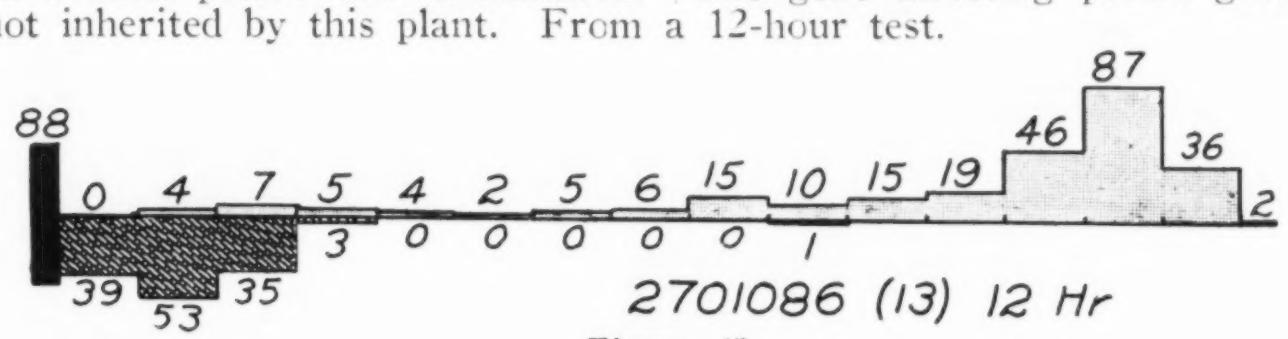



**Figure 17**

A similar distribution diagram from a 12-hour test of one of the $F_2$ plants 2701086 (13) in which the abnormalities of 27370 (1) reappeared. Though more of the pollen germinated than usual in the parent, the number of pollen tubes in the forward group (right hand half in the diagram) constitutes about 47 per cent.

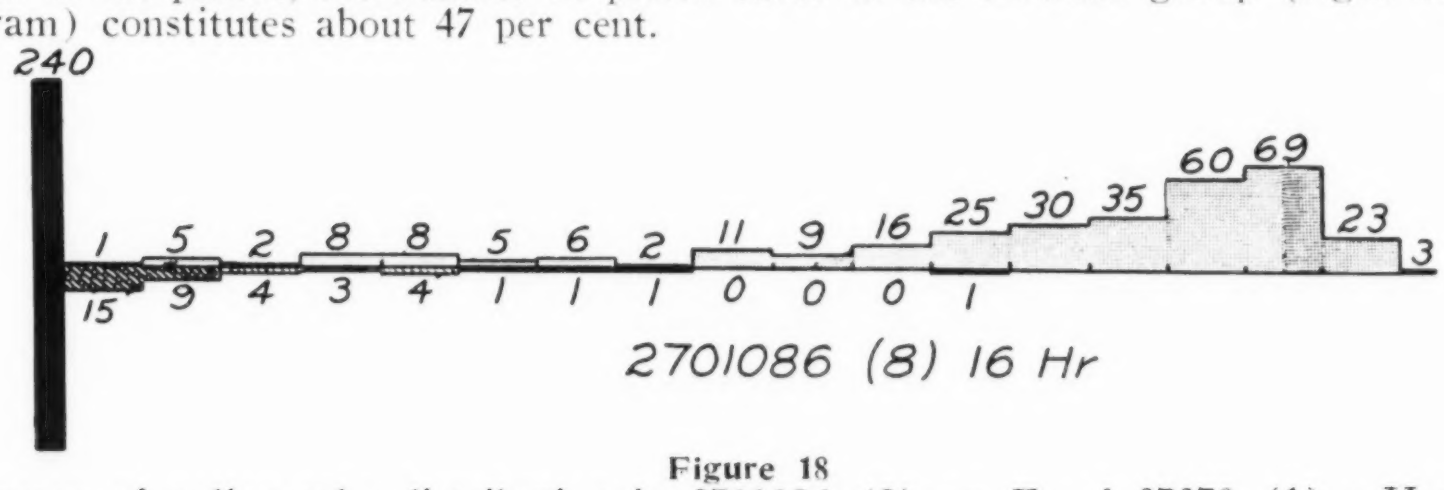



**Figure 18**

Diagram of pollen tube distribution in 2701086 (8) an $F_2$ of 27370 (1). Here the proportion of ungerminated pollen is higher than in Fig. 17, but there are fewer burst pollen tubes. From a 16-hour test.

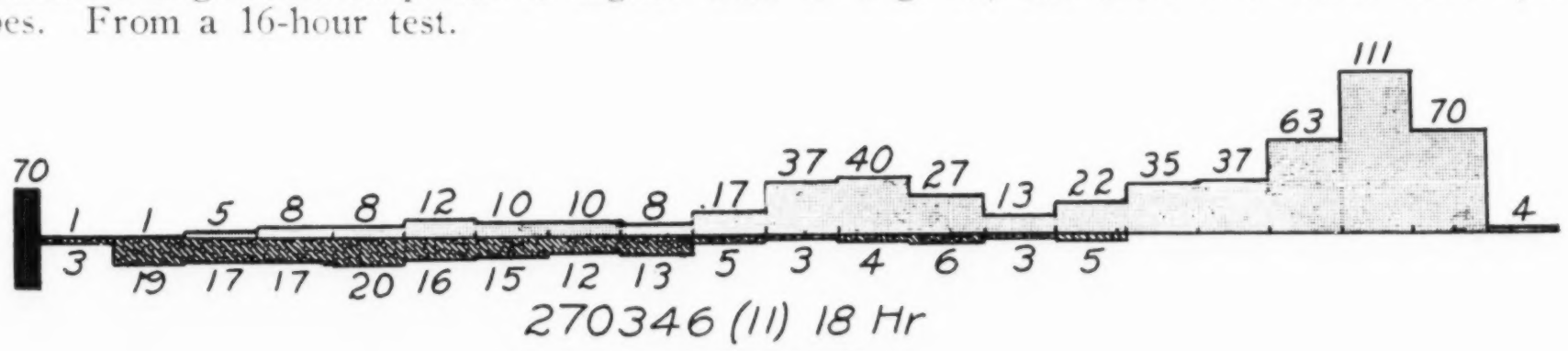



**Figure 19**

Diagram of distribution of pollen tube ends in 270346 (11), an $F_2$ of 27374 (6), from an 18-hour test. There are two modes but the second or slow-growing group has given rise to many burst pollen tubes as shown at the left.

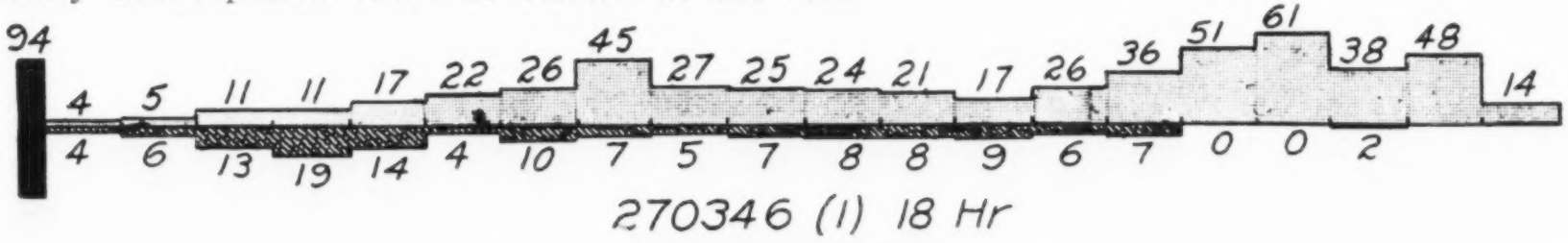



**Figure 20**

Diagram from an 18-hour test of 270346 (1) another $F_2$ of the same pedigree as Fig. 19, but in which there was not so much bursting of pollen tubes in the second mode.

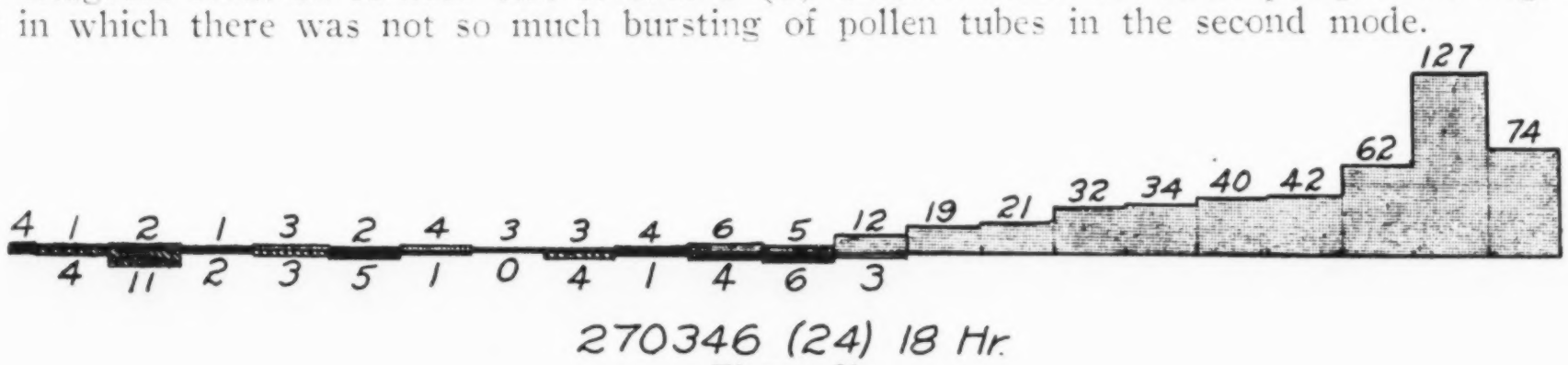



**Figure 21**

Diagram from an 18-hour test of 270346(24) an example of the condition when the gene for which 27374(6) was heterozygous was not transmitted.

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Figures 16 and 18
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growth.

grown on the stigmas of normal plants under uniform temperature conditions for various periods of time, usually for from 12 up to 18 hours. Slides were prepared from these tests by our dissection method and examined for abnormalities such as a high proportion of ungerminated pollen, delay in pollen germination, pollen tubes bursting within the tissues of the style in high proportions, a bi-modal distribution of the ends of the pollen tubes, and other conditions representing combinations between several of these conditions.

Figure 12 is the photomicrograph of a portion of the stigma pollinated with pollen from plant 27370(1). About half of this fully matured pollen failed to germinate. As mentioned above, in addition to the fully matured pollen grains whose cytoplasm stained deeply with the magenta stain, there were many empty pollen grains apparently devoid of protoplasmic contents. Except for the absence of germ tubes these resembled the empty exines left on the sigma after pollen germination, and were not included with the "fully matured pollen" recorded as ungerminated in our counts.

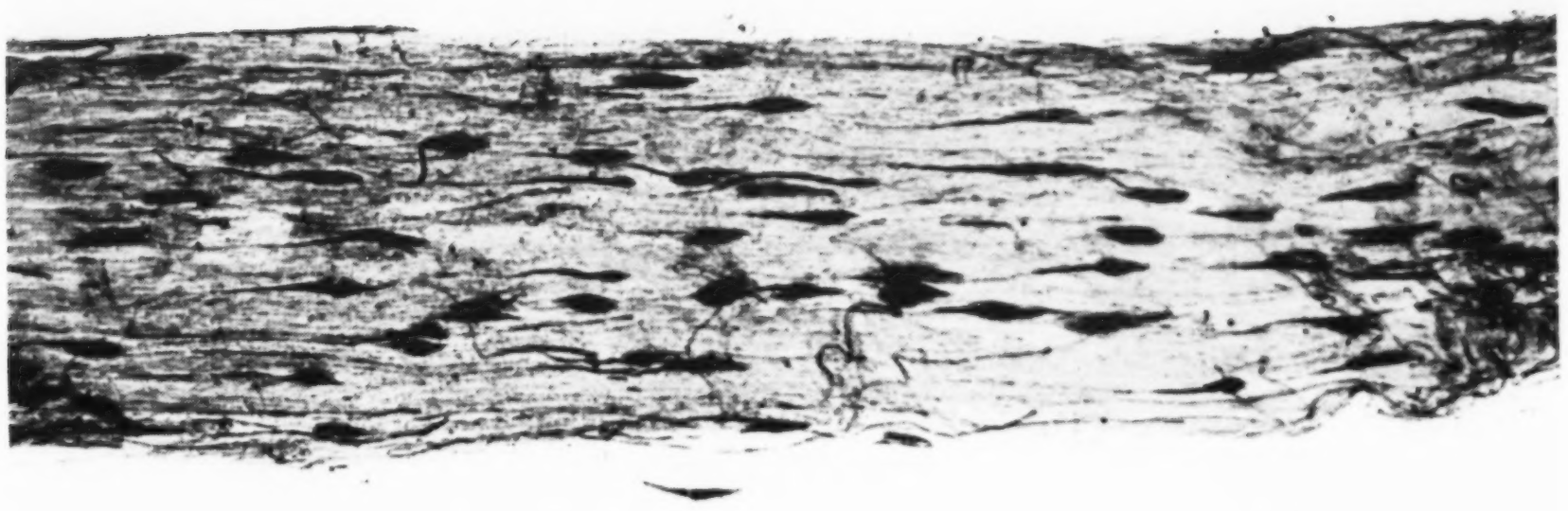
Figure 12 *A* shows the pollen tube distribution curve of 27370 (1) from a 14-hour test. This diagram was made by counting the ends of the pollen tubes within the style together with the ungerminated pollen grains remaining on the stigma, and recording them in the appropriate interval of distance from the stigma. Normal-appearing pollen tubes are plotted above the datum line and abnormal-appearing pollen tubes (mostly burst pollen tubes of the kind shown in Figures 13 and 16) are plotted below this line.

These counts were made with a microscope equipped with mechanical stage, using a 4 mm. objective, and an ocular with two properly spaced cross hairs. With this equipment the entire pollen-tube population could be counted throughout the length of the pistil, in transects running across the style. Only the forward ends of pollen tubes were counted and these counts were combined to give the much wider 2 mm. spaces of the distribution curves such as the one shown in Figures 12*A*, 13*A*, 17, 18, etc.

The large group of normal-appearing pollen tubes at the right (Figure 12*A*) are identified as normally growing gametophytes which would reach the ovary to accomplish fertilization. The heavy vertical bar at the left represents the number of ungerminated pollen grains. Some of these have remained perfectly round and unchanged—entirely ungerminated—while many other pollen grains have burst or become irregular in shape. Figure 12 shows both kinds of these, together with many empty exines, the outer spore coats of the pollen grains which germinated and gave rise to pollen tubes. The empty spore coats are abundant and more conspicuous in Figure 14, which is from normal pollen, where there were very few ungerminated pollen grains. Figure 15, an $F_2$ from another pedigree, is offered in this connection because the majority of the ungerminated pollen grains are unchanged in shape and because it shows clearly a very similar condition resulting from a gene which prevents pollen germination.

Since about half of the gametophyte population remains ungerminated as shown in Figures 12 and 12*A*, and nearly all pollen grains germinate when pollen of an untreated plant is similarly tested (Figure 14), we interpret this condition as due to an inherited change induced by radium treatment given to the pollen in 1927, from which plant 27370(1) was derived. Five independent tests of this $F_1$ plant made at various times during the summer of 1928 gave similar results, but a few of them showed that sometimes (in 18 hour tests) a part of the ungerminated pollen began to germinate after a time, and gave rise to pollen tubes which burst near the stigma. This condition is shown in Figure 13, and a distribution curve from this same test in Figure 13*A*.

The condition in the pollen of this plant was due to a gene for which plant 27370(1) was heterozygous, manifest-



**BURST POLLEN TUBES IN CENTRAL PART OF STYLE**

**Figure 22**

Central portion of the dissected style after pollination with 27374 (6) showing many burst pollen tubes. Fig. 19 shows a similar case in an $F_2$ from this plant, a test which appears nearly the same as this in the upper third of the style.

ing itself in the gametophyte generation. We know that it was not due to a chromosomal irregularity as is found in the pollen of $2n+1$ types where half of the pollen grains receive an extra chromosome since this plant was examined by Dr. Bergner and Miss Satina, and found to have 12 bivalent chromosomes. Furthermore, all $2n+1$ types thus far recognized have been easily distinguishable from normal plants. We may therefore presume that the pollen grains all had twelve chromosomes and that this difference, since it was inherited, was due to a gene. We classify genes of this kind as lethals of pollen-tube growth since pollen grains which carry such genes either fail to germinate or burst within the style after germination, making transmission through pollen impossible.

However, we found that this gene was transmitted through the eggs. In pedigree 2701086, which consisted of thirty $F_2$ plants grown from seeds of 27370(1) we tested 29 of them. In the pollen of thirteen of them pollen-tube distribution curves were obtained with abnormalities very similar to their $F_1$ parent. Figure 17 represents one of these in which the number of burst pollen tubes near the stigma, together with the ungerminated pollen grains, constitutes about half of the total count. Figure 18 represents another case in which there are very few burst tubes, but a larger number of ungerminated pollen grains. Tests of the thirteen plants, heterozygous for these abnormalities fell into one or the other of the two conditions represented by Figures 17 and 18, and it will be seen that these are essentially the same as the conditions in the parent, Figures 12*A* and 13*A*.

Eleven of the plants had pollen which gave perfectly normal pollen-tube growth tests. Figure 16 represents one of these. Here the conditions are essentially the same as in tests of ordinary $2n$ plants,[3] except that in Figure 16 only 18 pollen grains failed to germinate; usually a $2n \times 2n$ test shows a little more ungerminated pollen.

Six other plants in this pedigree showed a considerable number of the pale empty pollen grains mentioned in connection with plant 37370(1), whose proportion was estimated by Dr. J. L. Cartledge as 10 per cent in some cases, ranging up to 35 per cent in others. They may be discussed in a separate report on pollen abortion. These should probably not be considered in our summary, but we may state that of the five

which were tested, four showed a high proportion of burst pollen tubes and one a condition which may be classified as normal with regard to pollen-tube growth.

The ratio obtained in $F_2$ was therefore 11 with normal pollen-tube growth, to 13 with abnormalities closely resembling those of the $F_1$ generation. This probably represents a 1:1 ratio and is to be explained on the hypothesis that the abnormalities which we described as lethals of pollen-tube growth were inherited through the eggs but not through the pollen. Even if we should include the tests of all 29 plants in our summary, the ratio would be 12:17, but we would not be justified in assuming that this represents other than a 1:1 ratio on the basis of a pedigree of only 29 plants.

Plant 27374(6), an $F_1$ derived from pollen-tube treatment during growth (b), was tested a number of times and, though its pollen appeared perfect, it usually gave a bi-modal distribution curve similar to that of one of its $F_2$'s shown in Figure 20. This seems to indicate that there are two classes of pollen grains, those giving rise to the slow-growing pollen tubes and those giving rise to pollen tubes of normal growth rate. The counts show that these two groups of gametophytes are found in nearly equal proportions. Sometimes the pollen tubes of the second mode burst within the style, giving the appearance of Figure 11, when the bursting did not involve all pollen tubes in the second mode. Figure 22 is a photomicrograph of the middle portion of the style from a test employing the pollen 27374(6), under the conditions of bursting in which this abnormality affected the majority of the pollen tubes in the second mode.

The $F_2$ pedigree 270346 grown from seeds of 27374(6) contained 30 plants, 26 of which were tested for these abnormalities. We found that 12 of these were entirely normal. Their pollen always gave tests similar to that of Figure 21 or Figure 16, which are essentially similar in being uni-modal.

The other 14 were always either bi-modal, as in Figure 20, or showed the condition of Figure 19, in which a high proportion of bursting pollen tubes were found, with a corresponding reduction in the number of normal-appearing pollen tubes in the second mode. Though some of them showed conditions in which considerable pollen remained ungerminated (12.3 per cent in Figure 20), there were no examples which resembled Figures 12*A*, 13*A*, 17 or 18. Actual counts were made, though in all but two cases in this abnormal category the bi-modal character of distribution, or the conditions shown in Figures 22 and 19 were perfectly obvious without the counts.

If the slower growing pollen tubes should reach the ovary they might participate in fertilization, but they are under a distinct handicap. They must first survive the processes of gametophytic selection. Under conditions of pollination with an abundance of pollen they could not fertilize eggs since all of the ovules would first be entered by the faster growing pollen tubes. Under conditions of restricted pollinations in which a moderate quantity of pollen is applied to the stigma, there is some chance that they might have progeny. However, in any case the conditions of pollen-tube growth must be such that an excessive amount of bursting of pollen tubes does not occur. It should be pointed out that the conditions for conducting our tests of pollen-tube growth are very favorable, compared with those met with under field conditions in a garden culture. The pollinations in our tests employed only moderate amounts of pollen. Though we have not isolated a plant homozygous for this gene it does not seem entirely impossible. Whether such a plant would differ in any way from normal plants so that it would be recognizable somatically is also an open question, for it may be that these are genes which affect pollen-tube growth more or less exclusively. On the face of things it would seem advisable to look upon these genes as semi-lethals. By the term semi-lethals we mean to

imply that these are genes of a kind which may prove to be subject to a measure of experimental control in regard to their transmission.

An interesting fact which should be pointed out is that neither the 27370(1) plant nor any of its $F_2$ pedigree (2701086) showed any indications of a bimodal distribution of the pollen tubes. The pollen grains carrying the lethal gene either failed to germinate, or if they germinated they burst in the region near to the stigma. On the other hand, the pollen of 27374(6) and its $F_2$ progeny (270346) nearly all germinated. The abnormalities expressed in their pollen tubes were slow growth, resulting in a bi-modal curve of distribution often followed by a bursting of the second group which occurred at a point well down in the style. Not only is the demonstration that these abnormalities are inherited of particular interest, but also the fact that they reappear in the $F_2$'s in the form in which they were recognized in the $F_1$.

Plant 27373(3), an $F_1$ derived from similar treatment, may be taken as a control plant, one which did not carry genes affecting pollen-tube growth, though it was derived through the same processes of treatment. An $F_2$ pedigree 270320, grown from seeds of this plant had pollen which was likewise free from abnormalities of pollen-tube growth. Of the 23 $F_2$ plants tested, all were found to be normal, giving uni-modal pollen-tube distribution curves, resembling Figures 16 and 20.

Abnormalities of the kind described here are not met with ordinarily in $2n$ plants.[2,3] The pollen of homozygous normal plants give distribution curves which have been described previously, and tests of 40 field-grown $2n$ plants selected at random and made in 1927 showed the usual type of pollen-tube distribution curve. However, the pollen of $(2n+1)$ plants gives abnormalities somewhat similar to these, for here half of the pollen grains carry an extra chromosome. The plants with extra chromosomes may be easily recognized in the field cultures, and the fact that cytological examinations of the $F_1$ plants with which we were concerned showed 12 bivalent chromosomes is further proof that we were dealing with plants heterozygous for genes, and not extra chromosomes.

## Summary

We have described the following three conditions of genetic abnormalities obtained following radium treatment which have become evident in the male gametophytes after pollination: (1) Failure of half of the pollen grains to germinate. (2) Early bursting of half the pollen tubes. (3) Slower growth of half the pollen tubes to form a second mode of distribution. In the $F_2$ generations, segregation occurs in approximately 1:1 ratios in respect to normals and plants with the abnormality shown by their $F_1$ parents. These three abnormalities are probably due to recessive genes rather than to major chromosomal abnormalities since their $F_1$ parents had 12 closed bivalents at reduction and were normal in appearance. All three are viable in the egg cells. Conditions (1) and (2), however, are lethal to the male gametophytes affected and hence it should not be possible to secure plants homozygous for the genes in question. The other (3) is semi-lethal in that growth of the pollen tubes affected is not entirely prevented, although under normal conditions their growth is too slow to allow them to reach the ovary.

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# A DOUBLE SEX REVERSAL IN A HEN

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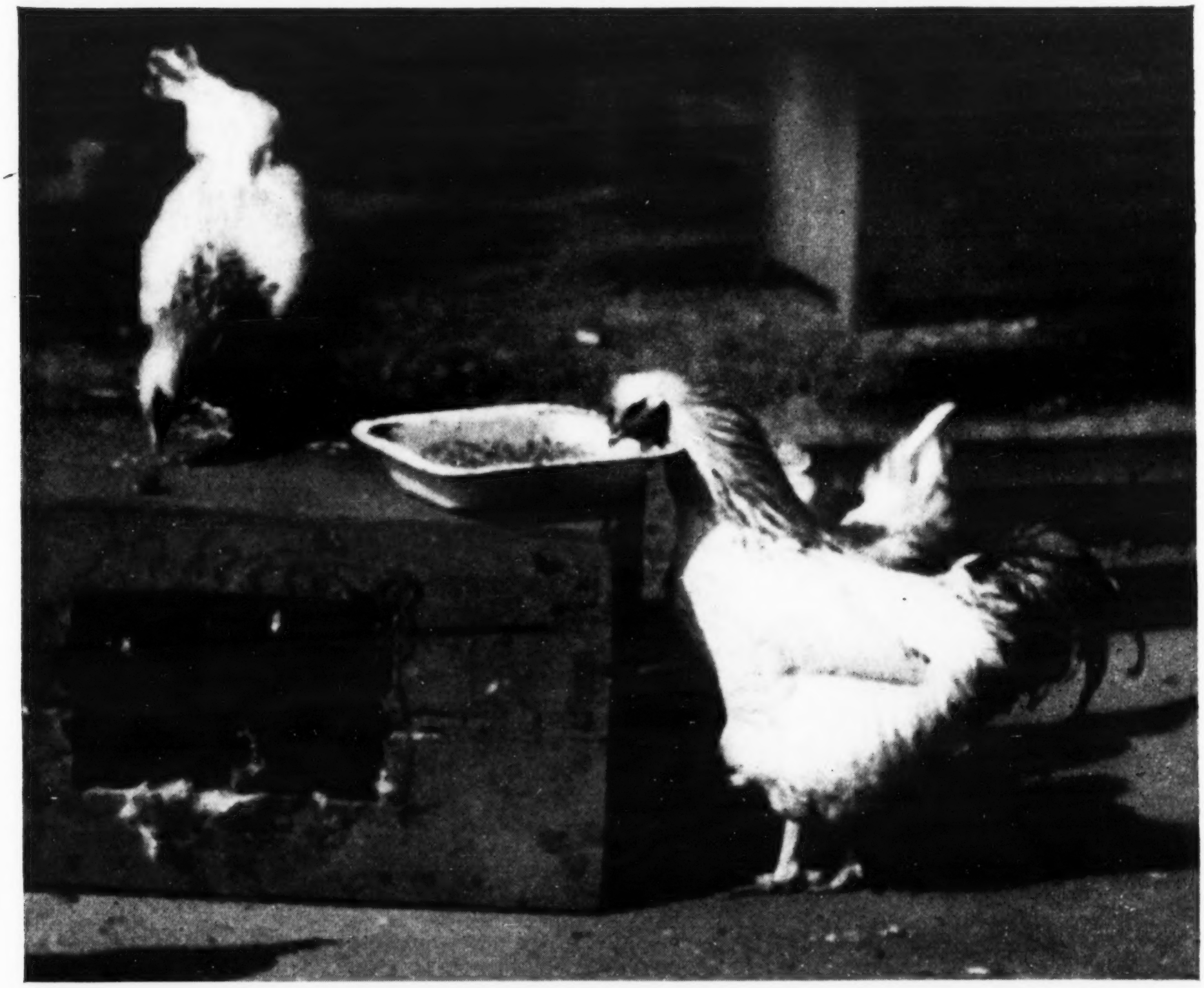

**A "COCK" WHEN THIS PICTURE WAS TAKEN**
**Figure 23**

View of the sex-reversed hen in the late summer of 1927—'She' did not moult the following fall, and the following spring 'she' was given a setting of eggs and proved an excellent mother! Later she reassumed hen plumage and laid regularly.

IN the majority of recorded cases of sex-reversal in the fowl the changes in the secondary sexual characters have been associated with definite lesions of the ovaries. Crew, however, states (*Vet. Joul.* 1922, vol. 78, p. 62) that hens may assume cock feathering and later after several moults reassume normal hen plumage without any demonstrable symptoms of ovarian disease. No detailed descriptions of such cases have been found in the literature, so it has been thought worth while to publish a short account of one which has been carefully observed throughout.

The bird, a light Sussex pullet, was hatched with seven other pullets in March, 1925. In October of the same year all eight commenced to lay and continued to do so till the spring of 1926. All then moulted and while the normal birds soon put on their new plumage this freak remained practically nude all summer and autumn Early in 1927 this bird slowly assumed male plumage with spurs (but no comb) and grew two inches taller than her sisters. She commenced to rule the farmyard (there was no other cock). She was observed calling the other hens

to food, accompanying them to the nesting boxes and shepherding them about. She was seen treading one of the other hens. During this time she laid no eggs. In the autumn of 1927 she failed to moult with the others and in the early spring of 1928 she was seen going to the nests and clacking. One dozen eggs were placed under her as an experiment. Eleven hatched and this ridiculous cock-like creature proved an excellent mother. In the late spring of this year she began to lay and continued to do so regularly throughout the summer. In the autumn she moulted and reassumed hen plumage. Her spurs persisted.

Throughout the winter of 1928 and spring of 1929 she laid regularly, mostly double-yolked eggs, and in May, 1929, she was killed and dissected.

Nothing abnormal was discovered in her internal organs. The ovary in particular showed no sign of past or present disease. Sections of all the ductless glands were cut and confirmed the macroscopic findings.

The photograph shows her as she was in the late summer of 1927. The tail and neck plumage are well shown and the spurs. Her carriage also is more like that of a cock than a hen.

*Editor's Note*: Cole in this Journal in 1927 (Vol. 18, pp. 96-106) described a somewhat similar case of a hen masquerading as a "laying cock," which subsequently returned to female plumage. While still in cock plumage she was mated to a White Leghorn rooster and produced fertile eggs, but she did not raise her own family.

## Genetics Interpreted

THE BASIS OF BREEDING, *by* LEON F. WHITNEY. Pp. 260, Price $3.00. Earl C. Fowler, Publisher. New Haven, 1929.

This book has been written more or less specifically for the layman who is supposed to have been baffled up to this time by the terrifying terms usually found in a production on genetics. The story is divided into two parts; the first dealing with the hereditary basis in sixteen chapters and the second part dealing with the physiological basis in eight chapters.

The common illustrative material used is the dog although examples are drawn from a large variety of material including plants. There is nothing new about the book unless it is the rather unusual way in which the subject matter is presented and the brevity of some of the discussions. Such a plan may appear to the average geneticist to be unorthodox but the reviewer is inclined to believe that the layman will find the author's presentation rather interesting, especially the chapter of practical questions at the end with text references to the answers.

*H. C. M.*

## William Bateson

"William Bateson had the rare distinction of combining great scientific attainment with an outstanding capacity for appreciating the artistic, literary and social sides of life. In the language of his own science he was "heterozygous." He was a lover of the classics, and a keen upholder of the value of a classical education; he was widely read in English and French literature, having a special admiration for Balzac, with whose works he was very familiar; although his judgment was not infallible, he was no mean connoisseur of art, and he possessed a fine collection of pictures, especially of early Japanese prints; a judge of good wine and good foods—qualities which distinguished his term of office as Steward of St. John's College—he was exceedingly hospitable and an admirable host." A biographical sketch of Bateson appeared in this Journal in 1926. Recently his contributions have been published in book form: *Scientific Papers of William Bateson*, *William Bateson, Naturalist*, and *Letters from the Steppes*.

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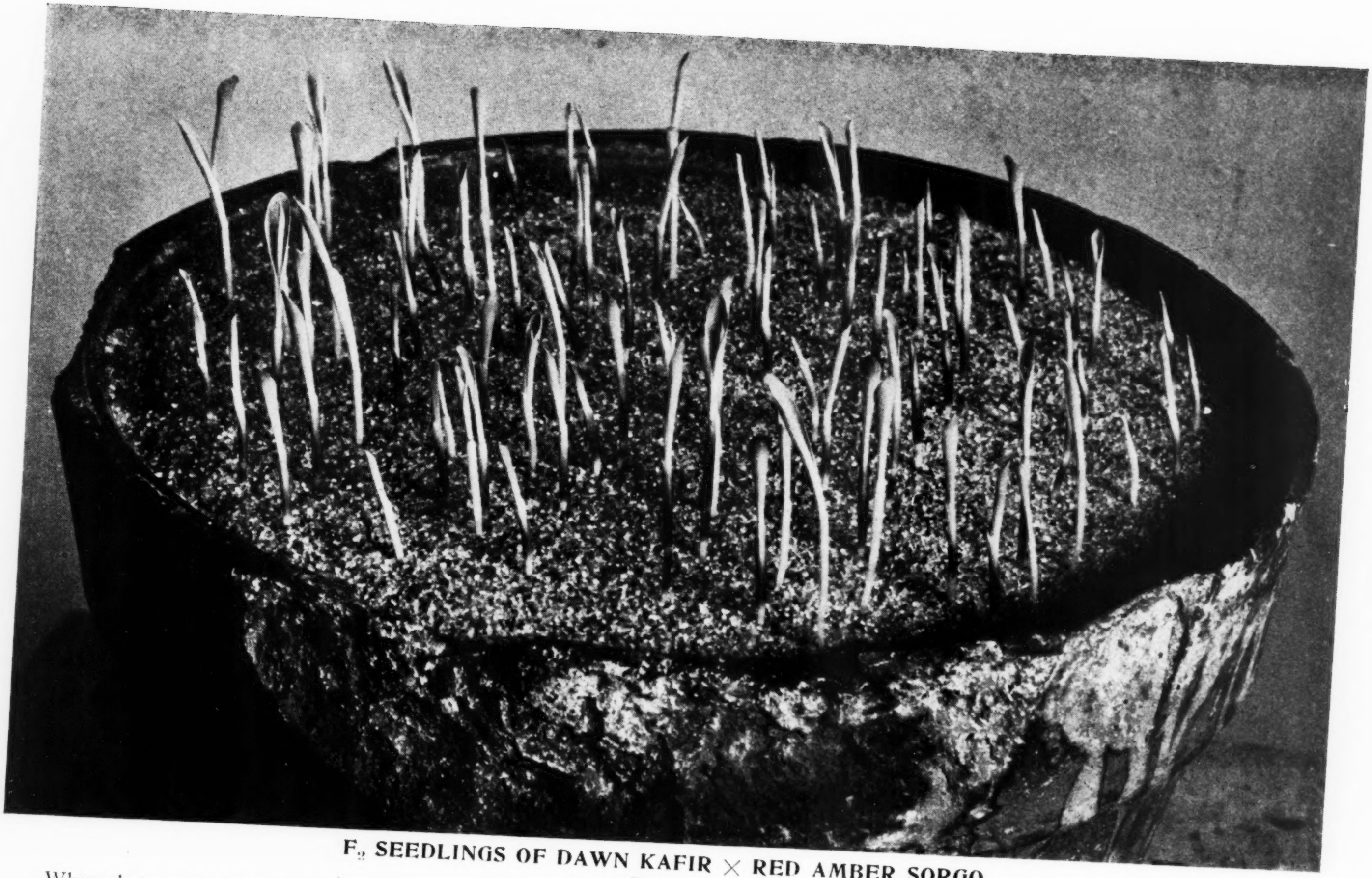
Engravers proofs of the portraits appearing on the cover of the Journal during 1930 may be obtained by members of the A. G. A. by application to the Managing Editor of the Journal.



**$F_2$ SEEDLINGS OF DAWN KAFIR × RED AMBER SORGO**

**Figure 24**

When photographed the seedlings were nine days old and the red and green types can readily be recognized. The seedlings were removed and counted when they were two weeks old and 66 were red and 30 were green.

# A NEW METHOD OF PRODUCTION AND DETECTING SORGHUM HYBRIDS

GEORGE M. REED

*Brooklyn Botanical Garden**

FOR several years I have been engaged in the study of smut resistance in sorghums. These plants are attacked by ten different species of smut, seven of which seem to be local in their distribution and as yet have not been recorded for the United States. Three species—covered kernel smut, loose kernel smut and head smut—are world-wide in their distribution and are more or less common wherever sorghums are grown. The covered kernel smut is unquestionably the most common, wide-spread and destructive disease of this group of plants. The head smut is interesting because the same species is recorded as a parasite on corn or maize, being especially destructive to this crop in Australia. There is definite evidence, however, that the head smuts of maize and sorghum are distinct specialized races[10].

The sorghums include very diverse types of cultivated plants derived from various parts of the old world. In northern China and Manchuria the Kaoliangs are extensively cultivated; in India, Jowar ranks third among the cultivated crops; sorghums are very widely distributed in Africa and are a staple crop of a large proportion of the native population. Broom corn has been cultivated in Italy for at least three hundred years and today is an important agricultural product in Italy and Hungary.

The sorghums, possessing a special value on account of their drought resistance, have been introduced into the United States from different parts of the world and are grown for a variety of purposes. From the agronomic standpoint, they may be grouped into four classes: 1. Broom corn, grown primarily for the brush used in the manufacture of brooms; the crop is mainly produced in Oklahoma and adjacent states. 2. Grass sorghum; the most important one is Sudan grass, which is grown for forage for stock. 3. Sorgo, or the saccharine sorghums, many of which are used for the manufacture of sirup, being grown for this purpose in most of the Southern States. In recent years these varieties have proved to be extremely valuable as forage plants for stock. 4. The grain sorghums, varieties valuable primarily for their grain, as Durra, Feterita, Kafir, Milo, Kaoliang and Shallu. Kansas, Oklahoma and Texas are the leading states for their cultivation.

## Smut Resistance of Sorghum Varieties

The most extensive data on the smut resistance of sorghums have been obtained with the covered kernel smut[9]. By far the larger number of varieties grown in the United States, including Broom corn, Sudan grass, Kafir, Durra, Sorgo, Shallu and most of the Kaoliangs, are susceptible to this disease. A few varieties, however, have stood out as resistant, the most conspicuous being Feterita, Milo, Darso and an occasional variety of some of the other groups. There is evidence, however, that specialized races of the covered kernel smut exist and, consequently, the problem of varietal susceptibility is associated with that of the existence of these specialized races.[13]

On account of the marked differences in the resistance and susceptibility of the varieties to known races of the smuts, it was thought that hybrids between certain ones would be favorable material for the study of the inheritance of resistance to smut. Accordingly, various crosses, such as Feterita ×

*Brooklyn Botanic Garden Contributions No. 58.

Sumac Sorgo, Blackhull Kafir × Standard White Milo and Feterita × Dawn Kafir, have been obtained and the susceptibility of the plants of the second, third and, to some extent, the fourth generation of these hybrids has been tested.

### The Flowers of Sorghum

Sorghums are not particularly easy plants to cross. The flower is small and the glumes are rather stiff. Further, when a successful cross is made, only one seed or grain results from the operation.

The inflorescence of the sorghum is a panicle. In some varieties, such as Feterita, Kafir, Durra and Kaoliang, it is relatively compact, while in others, such as Black Amber and Red Amber Sorgo, it is loose and spreading, a condition which reaches its maximum in Broom corn. The spikelets are arranged in pairs along the rachis. The basal spikelet of each pair is perfect, consisting of the two outer glumes enclosing the ovary with the two branched stigmas and the three stamens. The upper spikelet, borne on a short stalk, is sterile, or sometimes staminate.

The flowers at the apex of the panicle are the first to open and for a period of several days the flowers continue to develop towards the base. The stigmas of the flowers mature and push out first, followed later by the stamens. Probably the stigmas are generally pollinated by pollen from the flowers located higher up in the panicle. All sorghums seem to be entirely self-fertile, since heads, properly bagged, will regularly set an abundance of seed. In most cases, however, pollination takes place from different flowers on the same head and not from the same flower.

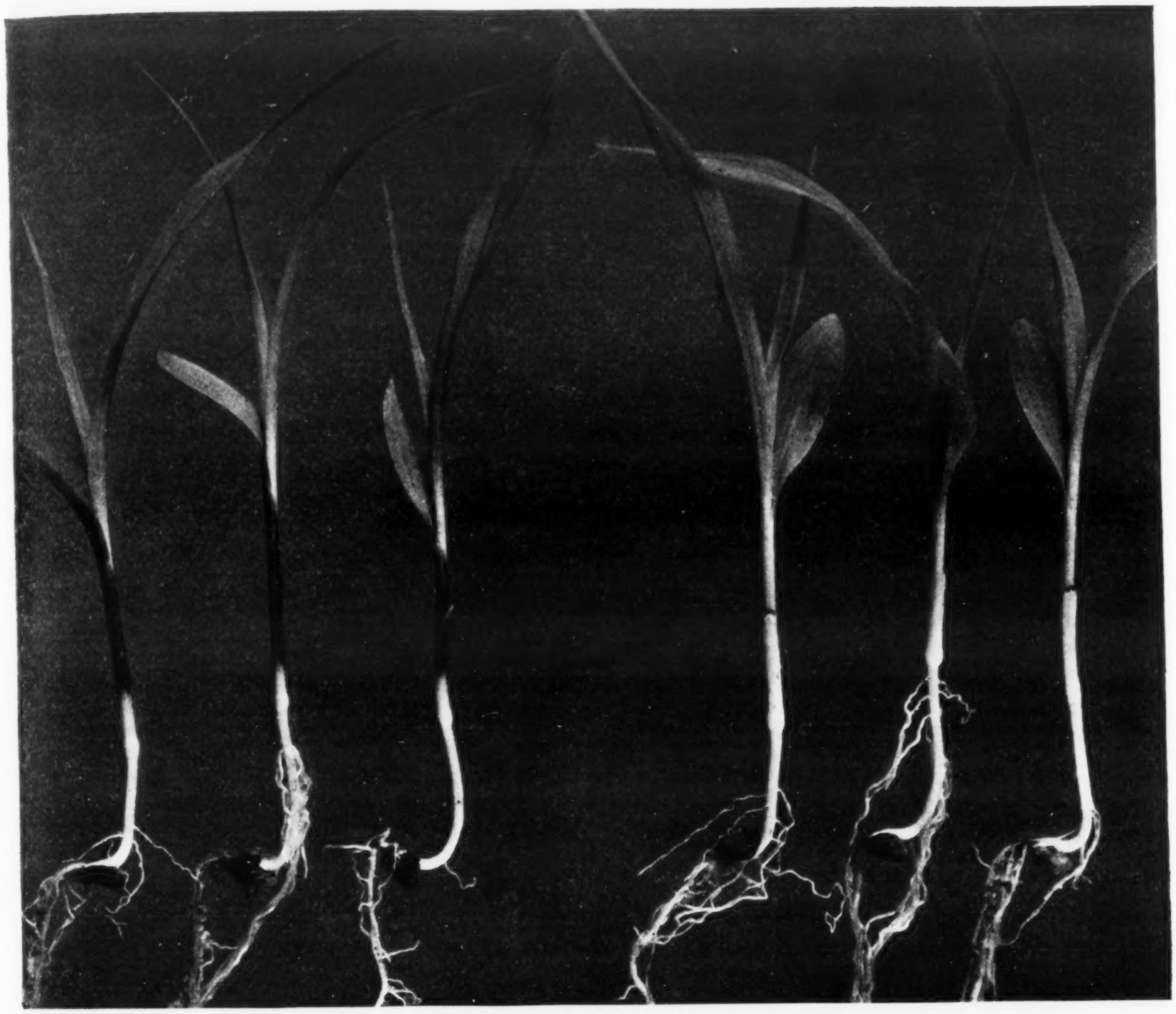
### Natural Crossing of Sorghum Varieties

The sorghums seem adapted to wind pollination and doubtless the pollen may be carried from one variety to another by this agency. To some extent, however, the pollen may be carried by insects, since various beetles and bees visit the flowers in great numbers. Natural crossing between the varieties is known to occur when different varieties are grown adjacent to each other. Ball[1] states that as high as 50 per cent of the seed may be cross pollinated when varieties flowering at approximately the same dates are growing side by side. The direction of the prevailing wind influences the amount of cross pollination. Graham[3] observed cross pollination between various varieties. The highest percentage which he obtained was 20 per cent. Karper and Conner[4] recorded the amount of natural crossing between Standard Yellow and Standard White Milo, two varieties of about the same height and whose panicles develop at approximately the same time. Out of a total of 13,430 plants, 788 were evidently cross pollinated with the Yellow Milo pollen, a percentage of crossing of about 6 per cent. Sieglinger[11] made further studies on cross pollination between these two varieties, and obtained a percentage of crossing of 5.38, or 276 plants out of a total of 5,125.

Vinall and Cron [14] have been successful in making numerous crosses of sorghums by artificial hybridization, and Vinall[15] has described a method for making the crosses. Sorghum hybrids are favorable material for the study of the inheritance of various characters, and several workers, as Conner and Karper,[2] Graham,[3] Ramanathan,[5] Sieglinger[12] and Vinall and Cron[14] have described their results.

### Color of Sorghum Seedlings

During the course of our experiments, the germination of the seedlings of most sorghum varieties was observed. It was noted that in some varieties, of which Dawn Kafir is a typical illustration, the young seedlings, after emergence from the soil, are pale yellow-green to green in color. When the seedlings are ten to fifteen days old, being at that time three to four inches tall with two to three leaves, the vivid green color is well defined in the leaves



**RED AND GREEN SEEDLINGS OF SORGHUM**

**Figure 25**

To the left are three red and to the right three green seedlings. The specimens actually photographed are $F_2$ plants of the cross Feterita × Red Amber Sorgo, and the contrast between the two types of seedlings is well shown.

and their sheaths. The first sheath or coleoptile, however, is pale yellowish green above the soil level, gradually shading to pale yellowish white below. Other varieties which produce green seedlings are Feterita, Shallu and Black Amber Sorgo. In Feterita we find a less brilliant green coloration than in some of the others, as the seedlings are often slightly flushed with a pinkish tone.

In contrast to these green seedlings of the Dawn Kafir are the seedlings of the Red Amber Sorgo. These, taken at the same age, have a very distinct red coloration of the emerged coleoptile and the sheath of the first leaf, the color even extending more or less into the base of the leaf blade. The part of the coleoptile below the soil is pale yellowish white and contrasts strikingly with the deep red color of the emerged portion. There is, therefore, a sharp contrast between the green seedlings of the Dawn Kafir and the red seedlings of the Red Amber Sorgo (Figures 24 and 25). Other red seedling types are Sumac Sorgo, Durra, Milo and several varieties of Kaoliang.

A second observation in our seedling germinations was the fact that the $F_2$ seedlings, grown from the seed of the $F_1$ plant of the hybrid Feterita × Sumac Sorgo were of two kinds—red

**HYBRID VIGOR OF SORGHUMS**
**Figure 26**

To the left are four plants of Dawn Kafir, a green seedling type, and to the right four hybrid plants grown from red seedlings taken from the same seed pan. The seed of all eight plants came from the same head of Dawn Kafir which had been pollinated with pollen from Standard Yellow Milo. The hybrid plants varied from 9 to 9½ feet in height. Yellow Milo plants grow from 6½ to 7½ feet in height.

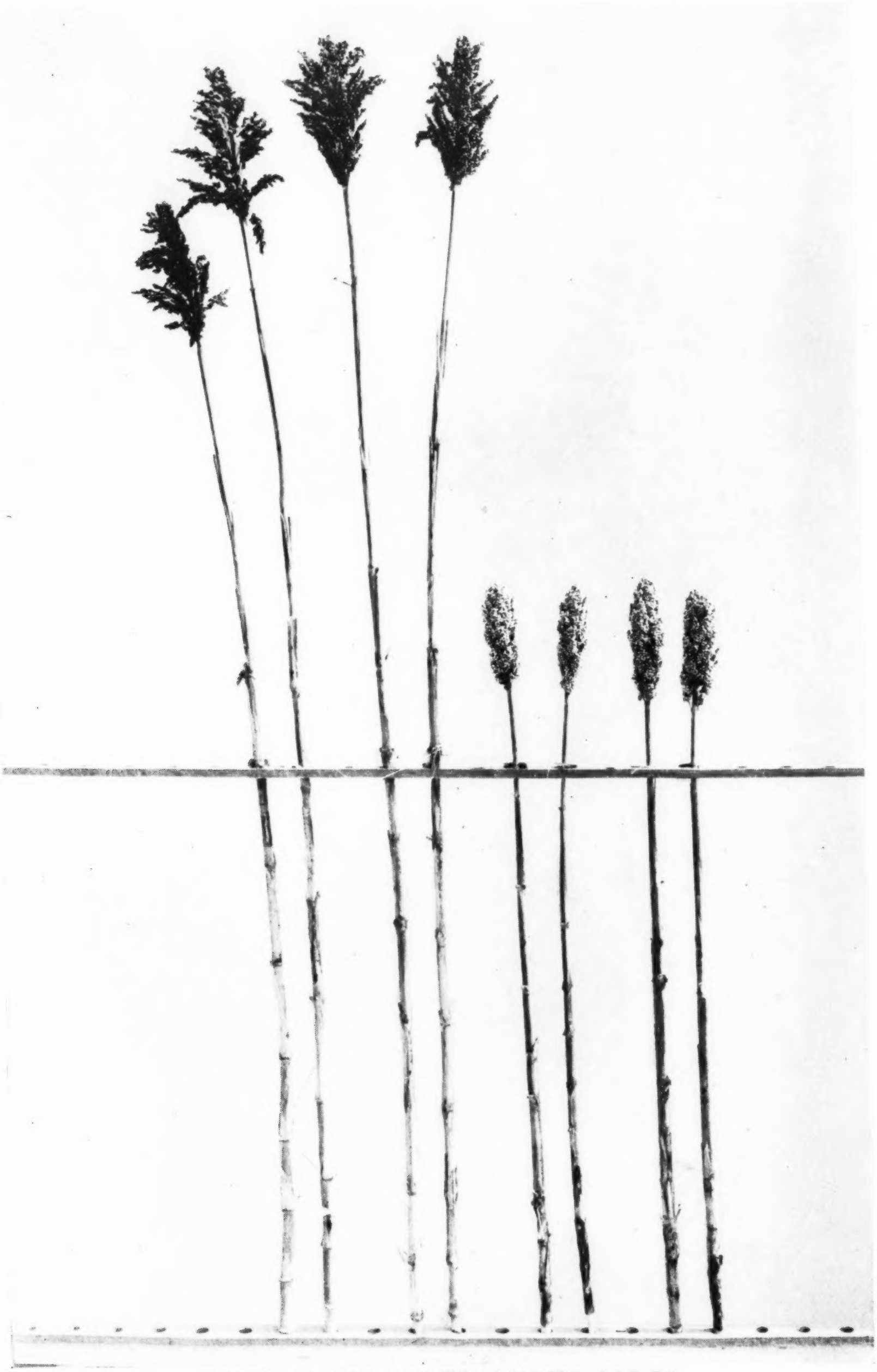
seedlings and green seedlings. Usually these could be readily distinguished from each other, the red seedlings greatly predominating. Several preliminary counts indicated a ratio more or less approaching three red seedlings to one green, with the red color dominant.

These two observations suggested a simple way of obtaining and detecting hybrids between certain desired sorghum varieties.

### Method of Cross-Pollinating the Varieties

The method of procedure was to select two varieties which differ in their seedling color, such as Dawn Kafir and Red Amber Sorgo. The heads of both plants, as soon as they began to emerge and before any flowers had opened, were carefully bagged. As soon as open flowers appeared, the pollen collected on the Red Amber Sorgo, the red seedling parent, was shaken over the head of the Dawn Kafir. Both heads were re-bagged and this operation of dusting on the pollen was repeated at two-day intervals several times, or as long as flowers continued to open on the green seedling parent.

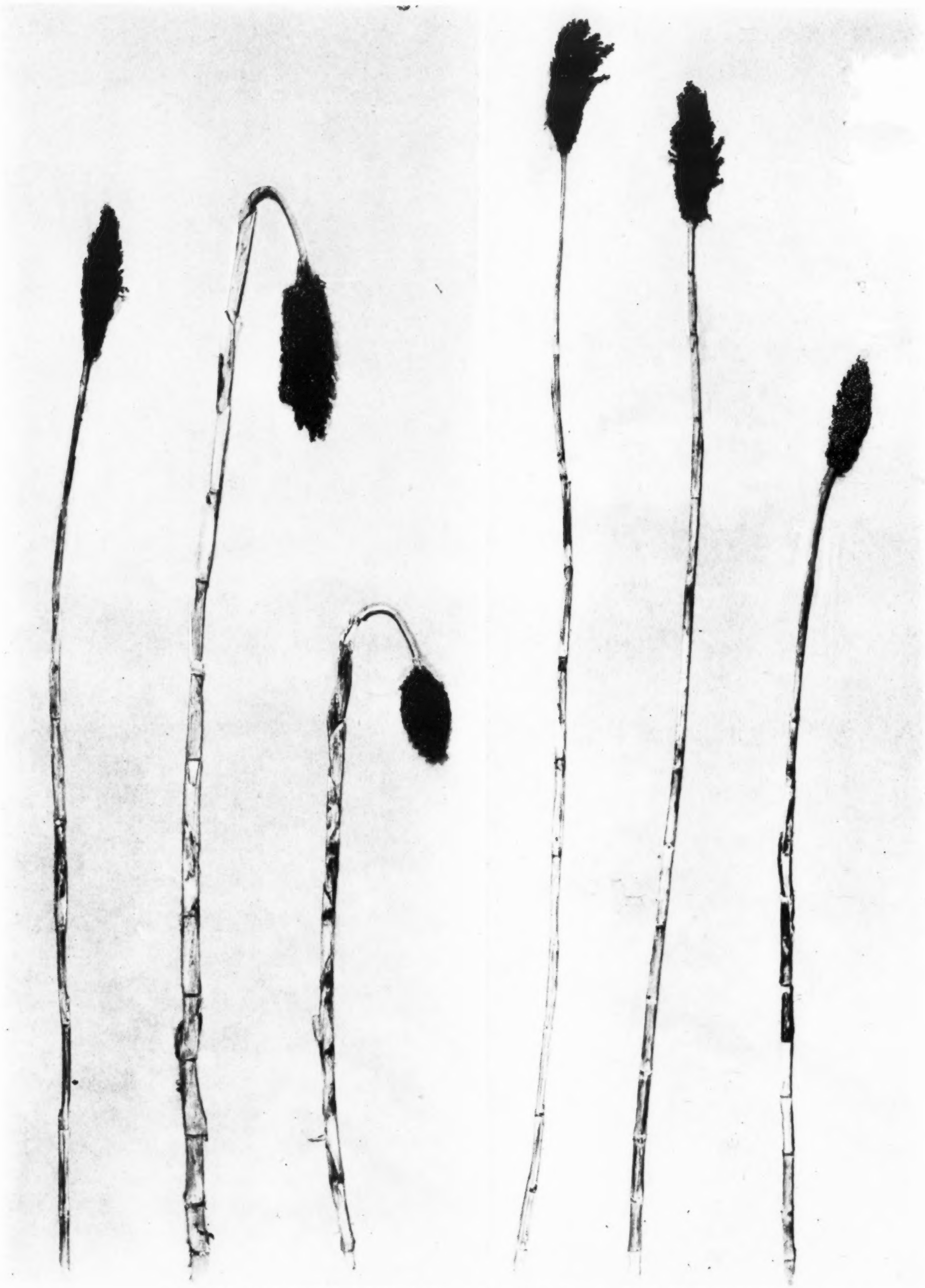
The procedure was based on the assumption that the foreign pollen would reach the stigmas of at least a few of the flowers at the right time in a viable condition and bring about cross pollination. It was expected that most of the flowers would be selfed, due to the relative abundance of pollen from other flowers on the same head. It was also probable that this pollen would be more viable and also reach the stigmas at the proper time as compared with that introduced from the other plant.



**DAWN KAFIR × RED AMBER SORGO**

**Figure 27**

To the left are two plants of Red Amber Sorgo and to the right two of Dawn Kafir. The seed of the four middle plants was taken from the same head of Dawn Kafir, which had been pollinated with pollen of Red Amber Sorgo. Plants 3 and 4 from the left came from red seedlings, while plants 5 and 6 came from green seedlings. Evidently plants 3 and 4 are true hybrids, while 5 and 6 resemble exactly the Dawn Kafir parent. Hybrid vigor is shown by the slightly increased height and also by the larger, more productive heads.



**HYBRID VIGOR AND INTERMEDIATE INHERITANCE**

**Figure 28**

*Black Amber Sorgo* × *Dwarf Yellow Milo.* A single plant of the Black Amber Sorgo is shown on the left, one of Dwarf Yellow Milo on the right, and the $F_1$ plant in the middle. The latter shows exceptional hybrid vigor.

**Figure 29**

*Feterita* × *Manchu Kaoliang.* The Manchu Kaoliang is shown on the left, the $F_1$ plant in the middle, and the Feterita on the right. So far as height is concerned, the hybrid plant is intermediate between the two parents.

### ›d of Detecting the Occurrence of the Hybrids

The head of the Dawn Kafir or other seedling parent used was permitted to mature. The seed was then harvested and later germinated in sand under favorable temperature and moisture conditions. If the method of producing hybrids was successful, it was expected that two types of seedlings from the same head would be obtained, most of them coming from selfed flowers being green, the characteristic color of the mother plant, and others red, due to the foreign pollen, and hence hybrids. The red seedlings were, of course, the young $F_1$ plants and were recognized by their dominant red color.

### Preliminary Experimental Data

In the fall of 1926 a head of Feterita, a green seedling type, was pollinated in the above manner with pollen from Standard White Milo, a red seedling variety. In the same way, a head of Blackhull Kafir was pollinated with Red Amber Sorgo pollen, and another head with pollen from Valley Kaoliang. The following spring the seed from these three heads was greminated. From the Feterita 257 seedlings were secured and 11 of these (4.2 per cent) were red in color. These seedlings were transplanted to the field and grown to maturity and they all proved to be hybrid plants. For purposes of comparison, ten of the green seedlings from the same seed pan were also grown to maturity and these proved to be typical of the female parent—Feterita.

From the head of Blackhull Kafir pollinated with pollen from Red Amber Sorgo, 1097 seedlings were germinated and four (0.36 per cent) were red, and from the head of Blackhull Kafir, cross-pollinated with Valley Kaoliang, a total of 694 seedlings were grown, of which 23 (3.3 per cent) were red in color. In both these cases the red seedlings were grown to maturity and in every case proved to be hybrids. Along with each set ten green seedlings from the same germinating pans were also grown, and these proved to be identical with the Blackhull Kafir or female parental variety.

These preliminary results indicated the effectiveness of the method of procedure. It is evident that if foreign pollen is introduced onto a head in the blossoming stage, at least some of the flowers will be cross pollinated, and the detection of the hybrids may be made at the time when the seed is germinated. Only those seedlings which appear to be hybrids need be grown to maturity and in this way the relatively large numbers of seedlings from self pollinated flowers may be discarded and the space and labor spent upon growing them saved. Further, the effort involved in the cross pollination is relatively little as compared with the tedious hand method of procedure which involves the emasculation of individual flowers and the later application of the desired pollen.

### Later Experiments

The results from the first year were so highly successful that essentially the same method was employed to secure additional hybrids between a large number of different sorghum varieties. During August and September 1927 the pollinations were carried out. The green seedling varieties used as the female included Darso, Feterita, Dawn Kafir, Sunrise Kafir and Dakota Amber Sorgo. Among the red seedling parents were Brown Durra, Barchet Kaoliang, Manchu Kaoliang, Red Amber Sorgo, Red Jowar and three varieties of Milo—Standard Yellow, Standard White and Dwarf Yellow.

The ripe heads were collected and early in the spring of 1928 the seed from these was germinated and the number of green and red seedlings observed. In practically every case both types of seedlings were secured although, as in the previous year, the number of green seedlings greatly predominated. The percentage of red seedlings varied from less than one per cent to as high as 18.3 per cent. The highest percentage was obtained when Dawn Kafir was used as the green

seedling parent. This variety with Red Amber Sorgo gave 18.3 per cent, with Dwarf Yellow Milo 16.6 per cent, and with Standard Yellow Milo 10.0 per cent red seedlings.

Most of the red seedlings obtained in these germination tests were transplanted to the field and grown to maturity. Along with them seed of both parents, as well as green seedlings from each seed pan were planted. Accordingly, there was a direct opportunity for observing the characteristics of plants from seed from the same identical head, arising from green and red seedlings respectively, growing alongside the original male and female varieties.

A total of 169 red seedlings from all crosses were obtained and of these 147 were grown to maturity. All except two proved to be hybrids. In 1929 an additional quantity of seed of a few of these hybrids was grown. In this year, 42 red seedlings from five of the different crosses were obtained. These were grown to maturity and all of them turned out to be hybrids. In each case ten green seedlings were also grown to maturity, and two of these turned out to be hybrids, not having been detected in the seed pan. These results certainly indicate a high degree of effectiveness in the method of producing and detecting the hybrids.

In 1928 a somewhat different procedure was tried out. Heads of Feterita and of Red Amber Sorgo were secured under the same bag and the plants were casually shaken at intervals during the subsequent days. The Feterita head was saved, the seed germinated and the young plants examined for red seedlings. This modification of the procedure was effective, for out of a total of 681 seedlings germinated, 56 (8.2 per cent) were red and when grown to maturity proved to be true hybrids.

The question may be raised as to why there was not a much larger number of successful cross pollinations. Perhaps the environal conditions furnish part of the explanation, since in general they were unfavorable. Each year the period during which the work was carried out was characterized by a great deal of rainy, humid weather. There was also the problem of applying the pollen at the proper time, when the stigmas were in a receptive condition, and no special studies were made as to its viability.

There are, of course, very obvious limitations of the method. In every case the female parent must be a green seedling type, since the red seedling color is the dominant character. If the pollination is carried out in the reciprocal manner, it would be impossible to distinguish between the true breeding red seedlings of the female parent and those that might be hybrids. Accordingly, reciprocal crosses are not possible by the method. However, the ease of obtaining a large number of desired crosses is so obvious that it has distinct advantages, and the reciprocal crosses may be secured by the more tedious single-flower method. The method of securing $F_1$ plants and their subsequent detection is effective. Only rarely is a hybrid plant overlooked or a mistake made in picking out a green type. It is evident the method is a very successful one for the purposes intended.

### Hybrid Vigor of the $F_1$ Plants

One of the striking features of some of the $F_1$ plants was their remarkable vigor as compared with the parental varieties (Figures 26, 27, 28). This was especially evident in crosses involving Dawn Kafir and Dwarf Yellow Milo. The $F_1$ plants grown averaged 7½ to 8 feet in height, while the Dawn Kafir plants were 3½ to 4½ feet and the Dwarf Yellow Milo 4 to 4½ feet; thus the $F_1$ plants had a height nearly equal to the combined height of the two parents. Dawn Kafir × Standard Yellow Milo also gave striking evidence of hybrid vigor. In this case, the $F_1$ plants varied from 9 to 9½ feet, Dawn Kafir from 3½ to 4½, and the Standard Yellow Milo from 6½ to 7½ feet. Black Amber Sorgo × Standard Yellow Milo and also Black Amber Sorgo × Standard White Milo showed distinct evidence of increased hybrid

vigor, the hybrid plants being 8 to 9½ feet in height, while the Black Amber Sorgo was 6 to 6½ and the Milo parents 7 to 7½ feet. The height of the $F_1$ plants of Feterita × Durra, Feterita × Red Amber Sorgo, and Dawn Kafir × Red Amber Sorgo, was about equal to that of the taller male parent. In the cross between Feterita and Manchu Kaoliang, the $F_1$ plant was somewhat intermediate in height between the two parents (Figure 29).

Not only was there a marked increase in the height of the stalk of some of the $F_1$ plants as compared with their parents, but the panicle or head was greatly enlarged. This resulted in an unusual increase in the number of seeds which were produced (Figures 27, 28, 30).

Accompanying this hybrid vigor was increased stooling and lateness of maturing. In most cases, the $F_1$ plant matured slightly later than the late maturing parent. In the crosses involving the varieties of Milo as one of the parents, there was a very marked delay in the maturing of the hybrid; in fact, it was so much so that good ripe seed in none of these crosses was obtainable, although the more or less immature seed gave a high percentage of germination.

### Inheritance of Seedling Color

Since the red color is dominant in the seedlings, it is interesting to know how it will be distributed among the $F_2$ population. Accordingly, large quantities of seed from different $F_1$ plants have been germinated in order to determine the occurrence and distribution of the two types of seedlings. The most extensive series was carried out during August and September 1929, when conditions appeared particularly favorable in the greenhouse. The days were bright, the temperature quite high, and the seedlings grew rapidly. The data could be obtained in about nine days, and the differences showed up clearly for at least a week longer (Figure 24).

Table I shows the number of $F_1$ plants of the different crosses, the total number of seedlings grown, the number of red seedlings, the number of green seedlings, and the percentage of the latter. In most cases the two types of seedlings could be readily distinguished. There were variations in the intensity of the red color, but ordinarily there was enough difference to permit a proper classification.

The lowest percentage of green seedlings obtained was 21.2 per cent with the cross Feterita × Red Amber Sorgo. In this case there was a total of 377 plants, of which 297 were red and 80 were green. The highest percentage of green seedlings recorded in the table was 36.3 per cent, in the hybrid Black Amber Sorgo × Dwarf Yellow Milo; 99 seedlings were grown, of which 63 were red and 36 were green.

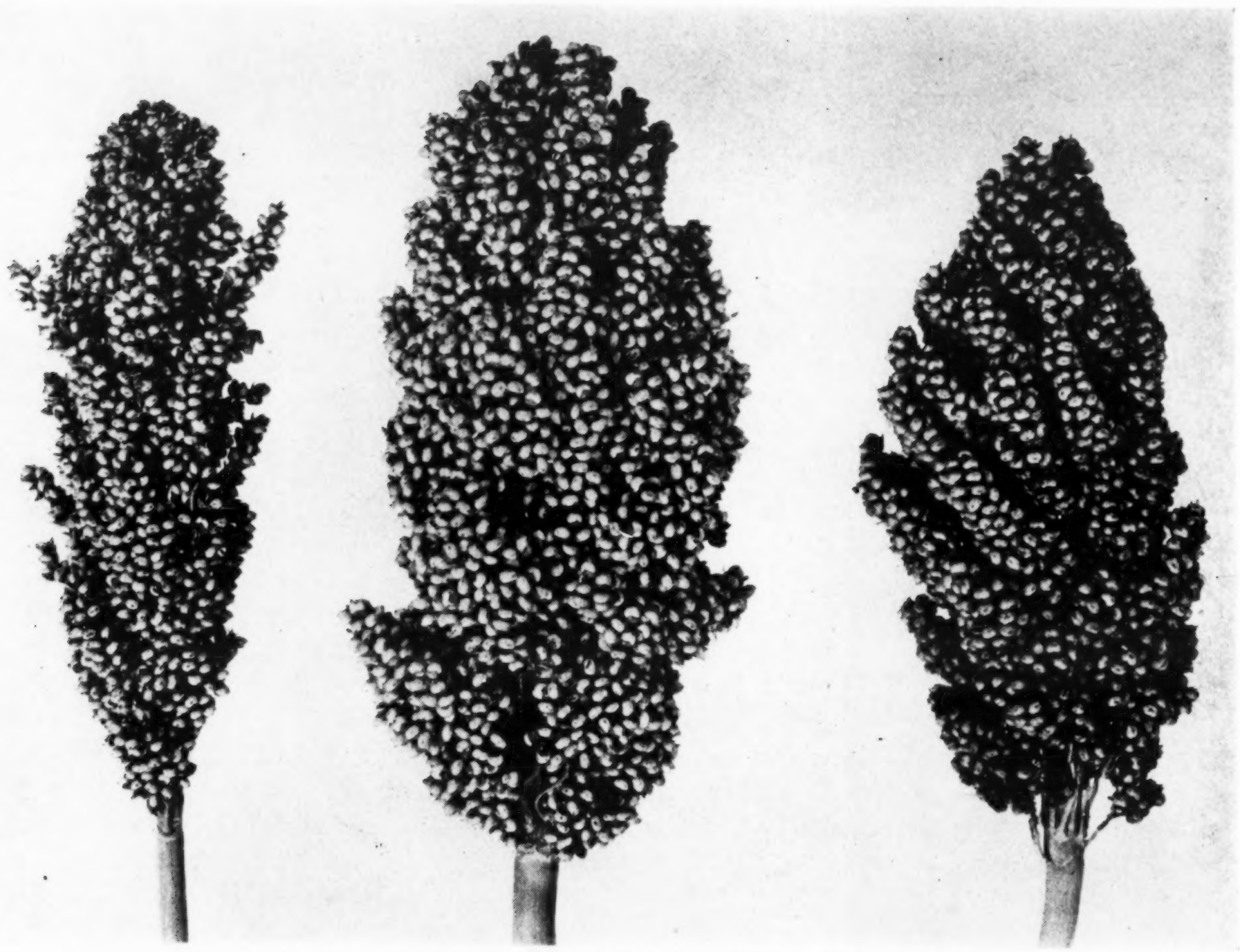
The combined data of the 31 crosses, involving 12 combinations of varieties, gave 3743 total seedlings, of which 2683 were red and 1060 green, the percentage of the latter being 28.3. It is evident from the germination tests of all these hybrids that segregation in the second generation occurs approximately in the ratio of three red seedlings to one green seedling.

### Value For Class Purposes

This particular material has proved of special value for the purpose of teaching students simple segregation of a character in the second hybrid generation. It is extremely interesting to watch the germination of the young seedlings and the gradual differentiation into red and green. The period during which they may be observed to advantage varies from one to three weeks. In most cases there is no difficulty in distinguishing the red seedling type from the green. There is further the advantage in the fact that the seedlings are very easily grown under ordinary laboratory conditions.

### Inheritance of Smut Resistance

Extensive data have already been obtained on the inheritance of the smut resistant quality in sorghum hybrids.[6, 7] In this study, however, several difficul-



**DAWN KAFIR × STANDARD YELLOW MILO**

**Figure 30**

On the left a head of Dawn Kafir, on the right a head of Standard Yellow Milo, and in the middle the greatly enlarged and productive head of the $F_1$ plant.

ties have been encountered. Successful infection of sorghums by the covered kernel smut is greatly influenced by environal conditions such as soil temperature, soil moisture and soil acidity.[8] It is extremely difficult to obtain the most favorable combination of these factors in order to secure the maximum number of infected susceptible plants.

Some of our data are recorded in the accompanying Table II. With the cross Feterita × Sumac Sorgo, $F_2$ plants inoculated with covered kernel smut were grown during each of the six years 1924 to 1929, along with the two parental varieties. The infection of the susceptible parent, Sumac Sorgo, varied from 38.3 per cent in 1924 to 86.1 per cent in 1926. The average for the six years was 50.9 per cent, 601 plants being inoculated. Feterita, during the same period, gave only one infected plant out of a total of 515.

The $F_2$ plants of the Hybrid 1-A gave percentages of infection varying from 23.5 per cent in 1928 to 69.6 in 1926. During the six years a total of 954 plants have been grown, of which 446 (46.7 per cent) were infected. With the second hybrid 1-B, the highest percentage of infection was 67.1 per cent in 1926, and the lowest 33.8 per cent in 1928; out of a total of 926 plants grown, 380 (41.0 per cent) were infected. It is especially interesting to note that high percentages of infection of the $F_2$ generation of the hybrid were obtained in those years when the Sumac Sorgo gave the greatest number of smutted plants.

While by no means conclusive, the results suggest that susceptibility is dominant, and if it were possible to secure approximately 100 per cent in-

fection of the susceptible Sumac Sorgo, we might expect that the second generation of the hybrid would give approximately three smutted plants to one normal.

The results with another hybrid between Blackhull Kafir and Standard White Milo are also interesting. Inoculated $F_2$ plants were grown from 1924 to 1927, and these gave infections varying from 6.2 to 17.1 per cent. During the four years, 620 plants were grown, of which 64 (10.3 per cent) were infected. During the same period the susceptible parent, Blackhull Kafir, gave 56.5 per cent infection or 216 plants out of a total of 382. Standard White Milo, on the other hand, gave completely negative results all four years, a total of 373 inoculated plants being grown.

The results with this hybrid suggest a very different situation as compared with the previous one. In this particular cross, the results obtained indicate that resistance is dominant and that, under the most favorable conditions, not more than one-fourth of the $F_2$ plants would be smutted.

Several of the descendants of the $F_2$ plants of these hybrids have been carried through to the third and fourth generations, and smut resistance has shown various combinations with the other characters of the two parental varieties. Completely resistant lines, resembling the susceptible parent in many characters, have been separated out. Thus it seems entirely possible to produce new types with any desired combination of morphological or agronomic characters, together with a high degree of resistance to smut.

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| | No. of Crosses | Seedlings | | | |
|---|---|---|---|---|---|
| | | Total No. $F_2$ | No. Red | No. Green | Per cent Green |
| Feterita × Sumac Sorgo | 2 | 194 | 151 | 43 | 22.1 |
| Blackhull Kafir × Red Amber Sorgo | 1 | 90 | 67 | 23 | 25.5 |
| Blackhull Kafir × Valley Kaoliang | 1 | 96 | 63 | 33 | 34.3 |
| Feterita × Brown Durra | 5 | 621 | 429 | 192 | 30.9 |
| Feterita × Manchu Kaoliang | 3 | 568 | 434 | 134 | 23.5 |
| Feterita × Red Amber Sorgo | 1 | 377 | 297 | 80 | 21.2 |
| Dawn Kafir × Dwarf Yellow Milo | 4 | 372 | 240 | 132 | 35.4 |
| Dawn Kafir × Standard Yellow Milo | 4 | 360 | 240 | 120 | 33.3 |
| Dawn Kafir × Red Amber Sorgo | 5 | 573 | 429 | 144 | 25.1 |
| Black Amber Sorgo × Dwarf Yellow Milo | 1 | 99 | 63 | 36 | 36.3 |
| Black Amber Sorgo × Standard Yellow Milo | 1 | 99 | 67 | 32 | 32.3 |
| Black Amber Sorgo × Standard White Milo | 3 | 294 | 203 | 91 | 30.9 |
| | 31 | 3743 | 2683 | 1060 | 28.3 |

**TABLE I—Inheritance of Seedling Color in Sorghum Hybrids.**

| Hybrids and Parental Var. | Year | No. Plants | No. Inf. | Percent Inf. |
|---|---|---|---|---|
| Feterita × Sumac Sorgo (Hybrid No. 1-A) | 1924 | 308 | 121 | 39.2 |
| | 1925 | 144 | 63 | 43.7 |
| | 1926 | 165 | 115 | 69.6 |
| | 1927 | 135 | 65 | 48.1 |
| | 1928 | 89 | 21 | 23.5 |
| | 1929 | 113 | 61 | 53.0 |
| | | 954 | 446 | 46.7 |
| Feterita × Sumac Sorgo (Hybrid No. 1-B) | 1924 | 307 | 112 | 36.4 |
| | 1925 | 145 | 53 | 36.5 |
| | 1926 | 140 | 94 | 67.1 |
| | 1927 | 153 | 53 | 34.6 |
| | 1928 | 68 | 23 | 33.8 |
| | 1929 | 113 | 45 | 39.8 |
| | | 926 | 380 | 41.0 |
| Sumac Sorgo | 1924 | 271 | 104 | 38.3 |
| | 1925 | 72 | 29 | 40.2 |
| | 1926 | 101 | 87 | 86.1 |
| | 1927 | 67 | 33 | 49.2 |
| | 1928 | 39 | 15 | 38.4 |
| | 1929 | 51 | 38 | 74.5 |
| | | 601 | 306 | 50.9 |
| Feterita | 1924 | 272 | 0 | 0 |
| | 1925 | 67 | 0 | 0 |
| | 1926 | 44 | 0 | 0 |
| | 1927 | 65 | 0 | 0 |
| | 1928 | 21 | 1 | 4.7 |
| | 1929 | 46 | 0 | 0 |
| | | 515 | 1 | 0.1 |
| Standard White Milo × Blackhull Kafir | 1924 | 198 | 14 | 6.9 |
| | 1925 | 130 | 14 | 10.7 |
| | 1926 | 163 | 28 | 17.1 |
| | 1927 | 129 | 8 | 6.2 |
| | | 620 | 64 | 10.3 |
| Blackhull Kafir | 1924 | 148 | 89 | 60.0 |
| | 1925 | 61 | 44 | 72.1 |
| | 1926 | 111 | 53 | 47.7 |
| | 1927 | 62 | 30 | 48.3 |
| | | 382 | 216 | 56.5 |
| Standard White Milo | 1924 | 223 | 0 | 0 |
| | 1925 | 72 | 0 | 0 |
| | 1926 | 58 | 0 | 0 |
| | 1927 | 20 | 0 | 0 |
| | | 373 | 0 | 0 |

**TABLE II (at right) Results with the $F_2$ Generation of Sorghum Hybrids inoculated with Sphacelotheca sorghi—1924—1929.**

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## World's Fourth Poultry Congress

THE World's Fourth Poultry Congress will be held at the Crystal Palace, London, England, from July 22 to July 30, 1930. The British Government cordially invites all persons interested in any aspect of poultry husbandry in any part of the world to be present.

The Crystal Palace, chosen as the venue of the Congress, is easily accessible from London, and a continuous service of fast electric trains, with a journey time of 15–20 minutes, will be run from several London stations. All business phases of the Congress—the paper reading sessions, national displays, livestock and commercial exhibits—will be held at this centre. Immediately the Congress proper terminates, a series of tours in England and Wales, Scotland and Northern Ireland, covering a total period of eleven days, will be arranged for delegates.

Five sessions will be held simultaneously, as follows:

(a) *Breeding and incubation;* (b) *Nutrition and rearing;* (c) *Diseases and their control;* (d) *Economics, including marketing;* (e) *Education and general.*

Sessions will be held in the mornings during the period of the Congress. A separate session for papers dealing with rabbits, pigeons, etc., will probably be arranged.

*All communications respecting the Congress should be addressed to the Congress Secretary, Dr. V. E. Wilkins, Ministry of Agriculture and Fisheries, 10, Whitehall Palace, London, S. W. 1.*

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